S. A. E. JOURNAL

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Transportation Meeting Marks Advance

Attendance of 460 Haulage, Railway and Highway Traffic Men Give It National Character—Cooperation Brought Nearer

WITH a registration of 460 members and guests, the 1928 S.A.E. Transportation Meeting goes into history as attracting the largest attendance of any meeting the Society has ever held devoted to the interests of the fleet operator and the maintenance engineer. All the sessions were equally well attended, the aggregate session attendance being more than 800. The registration list, which is published elsewhere in this issue, shows that the meeting was National in fact as well as in name. The Society may well be proud of its transportation division, not only on the basis of the attendance at the technical sessions, but on the basis of the valuable engineering papers presented.

The growing interest in Transportation Meetings is well exemplified by the fact that formal invitations inviting the Society to hold the 1929 Transportation Meeting in Philadelphia and in Toronto were received. George W. Elliott, general secretary of the Philadelphia Chamber of Commerce, telegraphed as follows:

"The Philadelphia Chamber of Commerce, on behalf of its 5000 members, extends to the Society of Automotive Engineers a cordial invitation to hold its 1929 Transportation Meeting in Philadelphia, 'Birthplace of the Nation' and 'World's Greatest Workshop.'"

AMONG THOSE AT THE MOTOR-HAULAGE SESSION

(Upper Row) Alfred Reeves, General Manager, National Automobile Chamber of Commerce, Discussed Cooperation; H. F. Bacon, President, Motor Truck Club of New Jersey, Presided; G. W. Daniels, United States Trucking Corp., Discussed Getting and Holding Business. (Lower Row) J. F. Galvin, President, Pennoyer Merchants Transfer Co., and Day Baker, Motor Truck Club of Massachusetts, General Discussers.

Interest in transportation affairs increased greatly in Philadelphia since the 1925 meeting there, and the Pennsylvania Section had already invited the Society to hold the 1929 meeting there. It had invited the Meetings Committee to hold the 1928 Transportation Meeting in Philadelphia, but, as it had never been held in Newark, J. F. Winchester proposed that, in view of the leading part which New Jersey has played in motor-vehicle transportation legislation, it be held there this year. The Committee decided in favor of Newark, and the success of the meeting confirms the wisdom of their decision.

Meetings Calendar

Production Meeting
Nov. 22 and 23, 1928, Book-Cadillac Hotel, Detroit

Aeronautic Meeting
Dec. 5 and 6, 1928, Hotel Stevens, Chicago

Aeronautic Operation Meeting
January, 1929, New York City

Annual Dinner
Jan. 10, 1929, The Waldorf-Astoria, New York City

Annual Meeting
Jan. 15 to 18, 1929, Book-Cadillac Hotel, Detroit

Buffalo Section Meeting—Nov. 13, 1928
Electric Arc Welding as Applied to Automotive Practice

Chicago Section Meeting—Nov. 13, 1928
Operation and Maintenance Relating to Methods of Reducing Maintenance Expense—Papers by the following: Norman Smith, The Consumers Co.; Walter Becker, Chicago Surface Lines; Harry Stillman, Casper Oil Co.; William Walma, Chicago Post Office; E. S. Anderson, Great Atlantic & Pacific Tea Co., and O. S. Caesar, Motor Transit Management Co.

Chicago Section Special Aviation Meeting—Nov. 27, 1928
To form Chicago Section Aviation Division

Cleveland Section Meeting—Nov. 19, 1928
Spiral-Bevel Gears, Hypoid Gears, Worm Gears, and Axle Deflection—Ernest Wooler, Timken Roller Bearing Co.; R. C. Wilson, The Gleason Works; L. R. Buckendale, Timken Detroit Axle Co.

Dayton Section Meeting—Nov. 13, 1928
Engine Production—V. M. Smith, Continental Motors Co.

Detroit Section Aviation Division Meeting—Nov. 5, 1928
The Amphibian—Grover Loening, Loening Aeronautical Engineering Corp.

Detroit Section Meeting—Nov. 22, 1928
Production Engineering Dinner during Production Meeting—Speaker: K. T. Keller
Subject: Production;—Men, Methods and Machines

Metropolitan Section Meeting—Nov. 15, 1928
Body Designing and Trend of Body Design—Amos E. Northup, Willys-Overland Co.
Commercial Car Design—Roy A. Hauer, Mack International Motor Truck Corp.
Paint and Varnish for Finishing and Lacquer Finishing—Representative from the Glidden Co.

Milwaukee Section Meeting—Nov. 7, 1928
Modern Trends in Automotive Engines—H. L. Horning, Waukesha Motor Co.

New England Section Meeting—Nov. 13, 1928
Joint Meeting, New England Section of the S. A. E., and New Haven Section of the A. S. M. E.
Automobile Dynamometer Tests at Mason Laboratory—H. W. Best, Yale University
Air Resistance of Automobiles—Prof. E. H. Lockwood, Yale University
Aviation Engines—A. Willgoos, Pratt & Whitney Aircraft Co.

New England Section Meeting—Nov. 21, 1928
Relation of Wheel Alignment to Premature Tire Wear—A. E. Feragen, A. E. Feragen, Inc.

Indiana Section Meeting—Nov. 8, 1928
New Iron Alloys or High-Strength Cast Irons—D. M. Houston, International Nickel Co.; Oliver Smalley, Neonite Metal Engineering Co.

Pennsylvania Section Meeting—Nov. 13, 1928
Brake Meeting—Led by John Warner, Studebaker Corp. of America
Papers by P. M. Heldt, Chilton Class Journal Co.; H. H. Allen, Bureau of Standards, and Paul Dumas, Chilton Class Journal Co.

Southern California Section Meeting—Nov. 9, 1928
Motor Overhauling—John E. Van Sant, Paul G. Hoffman Co., Inc.; M. C. Foster, Standard Oil Co. of California

Washington Section Meeting—Nov. 21, 1928
Motor-Car and Truck Maintenance

INVITED TO MEET IN TORONTO

At the Thursday morning session, A. S. McArthur of the Toronto Transportation Commission, formally invited the Society to hold the 1929 meeting in Toronto, and the following telegram, received by Mr. McArthur on the last day of the meeting from D. W. Harvey, of the Commission, was read by Chairman Horner:

"On behalf of the Toronto Transportation Commission, I would like to confirm the invitation you have extended to the Society of Automotive Engineers to hold its meeting in Toronto in October next year. It will be our pleasure to do everything possible to make the meeting a pleasant one."

TO WHOM CREDIT IS DUE

Great credit for the successful Transportation Meeting is reflected on Chairman F. C. Horner, of the Transportation Meeting Committee, and the other members of the Committee, the speakers and Session chairmen, the Operation and Maintenance Committee and the Reception Committee.

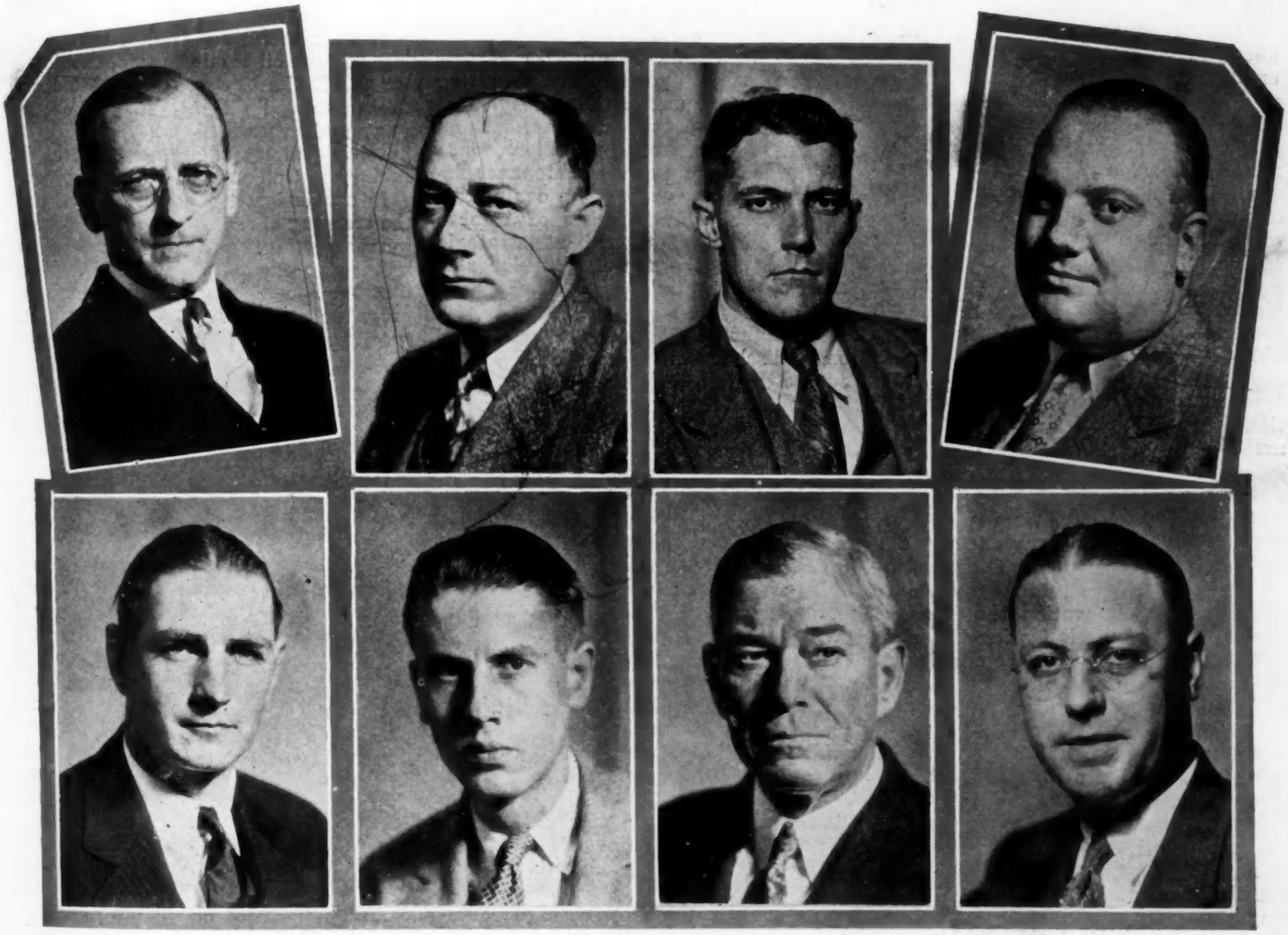
The Motor Truck Club of New Jersey contributed very largely to the success of the meeting, President Bacon presiding at the joint session and Secretary A. D. Way serving on the Transportation Meeting Committee and taking an active part in arranging the technical program and the detail plans. C. J. Fagg, of the Commerce and Trade Bureau of Newark, and C. E. Holgate, of the Newark Automobile Association, also did their utmost in making the meeting an outstanding success. The Public Service Corporation, represented on the Committee by Martin Schreiber, also deserves credit for the fine way in which it supported the meeting.

Following is a complete report of the meeting by sessions, including the Transportation Banquet and the Holland Tunnel inspection trip.

Motorcoach Operating Methods

Practices on Municipal Transcontinental Services Described and Discussed

SALIENT features of both short-haul and long-haul passenger-transportation by motorcoaches were presented at the Motorcoach Transportation Session held Wednesday morning, Oct. 17. A. T. Warner, of the Public Service Corp. of New Jersey, treated the short-haul phase. His paper is printed in full elsewhere in this issue of THE JOURNAL. A paper by W. E. Travis, president of the Yelloway-Pioneer Transportation System, Inc., of Oak-



SOME OF THE PROMINENT TRANSPORTATION ENGINEERS AT THE NEWARK MEETING

(Upper Row, Left to Right) R. H. Horton, of the Mitten Management, Philadelphia; H. W. Kizer, of the Texas Co., New York City; D. C. Bacon, of the New York, New Haven & Hartford Railroad, New Haven; A. H. Krender, Indiana Refining Co., Lawrenceville, Ill. (Lower Row) R. J. Collins, Kansas City Power & Light Co.; D. K. Wilson, Utica Gas & Electric Co.; H. V. Middleworth, Consolidated Gas Co., New York City; and F. W. Herlihy, United Electric Railways Co., Providence, R. I.

land, Cal., dealt with the methods now used by his company in transcontinental service. In the absence of Mr. Travis, this paper was presented in substance by his assistant, F. C. Murdock. Martin Schreiber, of the Public Service Corp. of New Jersey, was chairman.

Supplementing Mr. Warner's paper, Joseph Crawford, supervisor of transportation for the City of Newark, said that the short-haul phase of transportation supplies life and energy to the community it serves, bringing to the business section the mechanics, office workers and laborers without whom business would lapse. These employes must be served promptly and efficiently or they will become dissatisfied and seek employment in some other locality. Success of the short-haul business depends upon expert knowledge of working conditions in the municipality served, such as the number of people employed in a given area, the number employed in each industry or business in that area, where the people live, the routes that serve them best and the hours of their employment. One essential feature is to remember that the short-haul passenger is always in a hurry to go to and from his place of employment and his places of amusement. He expects both speed and safety.

Mr. Crawford said that steady riders are the backbone of the short-haul business. Another important contribution of patronage comes from the apartment-house dwellers who prefer the use of local transportation to walking to public garages for their own automobiles. The speaker suggested that a better means of designating the individual short-haul lines be developed. He acknowledged that the numeral system has good features, but called attention to the fact that these do not mean much to strangers.

Street-Cars for Peak Loads

Commenting on Mr. Warner's paper, H. C. Eddy, street-railway engineer for the Board of Public Utility Commissioners for the State of New Jersey, said that, from his observation, the gasoline-electric motorcoach is by far the most satisfactory for city service and is the type most popular with the public. He mentioned its smooth operation and said that the feature of comparative noiselessness is a prime reason for its popularity. He stated also that, although the field of the motorcoach is broad and is expanding and the vehicle has reached a marvelous degree of development in design and in fields of usefulness, he has yet to see a vehicle that can efficiently and economically handle mass transportation as it exists in our cities and larger communities today better than does the modern electric-railway car in its various forms.

In the further discussion of Mr. Warner's paper, L. H. Palmer, vice-president and general manager of the Fifth Avenue Coach Co., of New York City, commended the efforts of Mr. Warner's company in coordinating the different types of transportation equipment within its territory, such as motor-vehicles and street-cars, to give a rounded-out and unified transportation service in the communities in which these vehicles operate. He stated his belief that the street-car is the more effective means for heavy peak-load transportation, because of the feasibility of using trains of several cars for such service. Expediting the movement of public passenger-carrying vehicles will expedite the movement of all traffic on the streets, to the advantage of the users of vehicles of all classes, in Mr. Palmer's opinion.

Transcontinental Coach Service

Development of the system of operation and maintenance of the transcontinental motorcoach passenger service given by the Yelloway-Pioneer Transportation System has gone hand in hand with the development of the standard motorcoaches which the company builds for its own use, Mr. Travis explained in his paper. The operating method is not unlike that of a transcontinental railroad, the system being divided into operating divisions, each equipped with its own maintenance facilities and necessary spare equipment, and a reasonable number of reserve vehicles being stationed at strategic points along the route. Regular stations are maintained at all of the main cities along the route, and other places are designated where the vehicles take on or discharge passengers in the various settlements.

The vehicles arrive and depart on schedules that are adhered to very closely. An attempt is made to maintain an average speed of 32 m.p.h., but the legal speed-limit in any State is not exceeded and, where no legal limit is specified, the maximum speed at which the drivers are allowed to run is 40 m.p.h. Barring mechanical difficulties, a driver can make his schedule on time, and the drivers are penalized for crowding the speed limit to make up lost time between stations.

Reserve or "stand-by" equipment is available within a 2-hr. run of any point of need on account of breakdown on the road. In portions of the route where the population is reasonably dense, emergency men or "trouble shooters" are available who can respond to calls from the drivers for minor repairs en route. Many passengers desire to travel the entire route in the same coach but, since this is impossible for maintenance reasons, vehicles as nearly uniform as possible are provided. All baggage is checked, small luggage being carried in overhead racks inside and bulky luggage in a covered baggage-carrier in the rear on the roof.

With regard to operating conditions, after describing climatic and road conditions along the route from Los Angeles east and the various problems of design, power, and maintenance that are influenced by these conditions, Mr. Travis described the special equipment, such as four-wheel brakes, balloon tires and features that promote passenger comfort, including reclining chairs and forced ventilation.

Maintenance Along the Way

Details of the maintenance methods practised by the company included a description of the plan whereby so-called "A" maintenance-stations are provided at division points, where the vehicles are thoroughly inspected, cleaned and lubricated. The "B" maintenance-stations are located at points 200 to 250 miles apart over the entire system; here inspection is made of the important parts of the vehicle for reasons of safety, and attention is given to lubrication. No vehicle is ever allowed to leave an "A" or a "B" station, according to Mr. Travis, without having had the oil level checked, the radiator filled, the tire pressure tested and the wheel bolts tightened. The company endeavors to do all general overhauling and major-repair work at its factory in Oakland, Cal., or at Chicago.

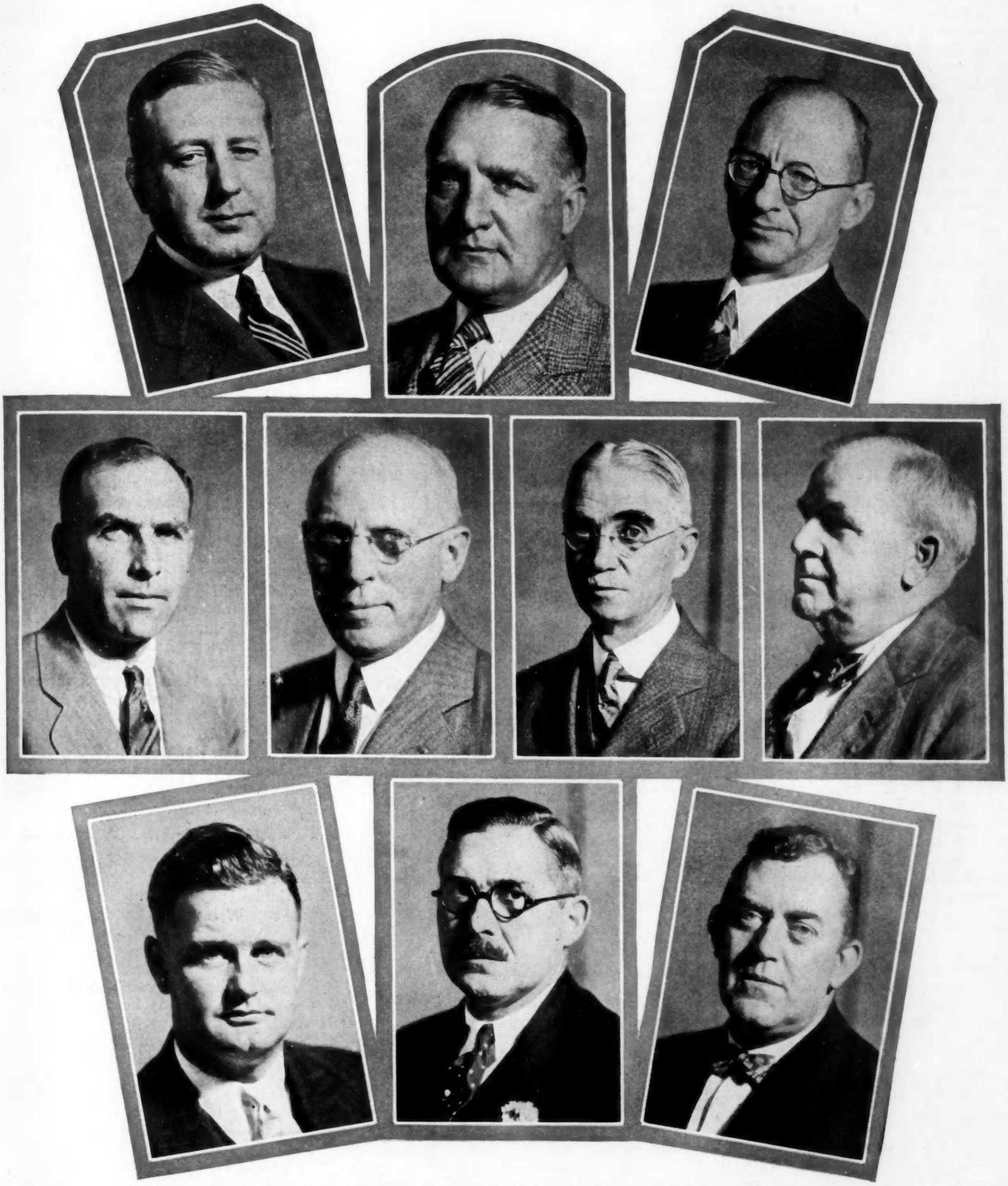
In conclusion, the author stated that the training of men to handle the maintenance of the vehicles at outlying stations has been a difficult problem, but that the company has been able to improve conditions in this respect. Inspection and maintenance of the equipment are regarded as the keynote of long-haul transportation. This applies not only to vehicles but to each piece of operating equipment and to the stations and operating methods.

Reclining Chairs Now—Berths Next

F. C. Murdock, discussing Mr. Travis' paper, said in part that the development of long-haul motorcoach transportation is a direct outgrowth of the horse-drawn stage in the West, and of the extension of suburban transportation lines in the East, together with the development of tourist travel.

One of the first things that interests the passenger is the kind of seat provided in the motorcoaches. This has different positions for reclining and also can be adjusted by moving it backward or forward to lengthen or shorten the leg-room. Regarding ventilation, he said that air is forced into the vehicle and, when necessary, is heated to maintain an even temperature regardless of the atmospheric temperature.

The company operates 600 vehicles, inclusive of spare vehicles. Coaches on long-haul transportation work from



SPEAKERS AND DISCUSSERS AT THE MOTORCOACH TRANSPORTATION SESSION

(Upper Center) Martin Schreiber, General Manager in Charge of Plant of the Public Service Coordinated Transport Co., of Newark, Who Presided at the Session; (Upper Left) F. C. Murdock, Vice-President of the Capital Bus Terminal, Who, Representing W. E. Travis, of the California Transit Co., Discussed Long-Haul Transportation; (Upper Right) A. T. Warner, General Manager in Charge of Traffic of the Public Service Corp. of Newark, Who Discussed Short-Haul Transportation. Included Among the Transportation Engineers Who Discussed the Papers Were (Middle Row, Left to Right) E. J. Graham, of the Public Service Co. of Colorado, Denver; N. D. Ballantine, Consulting Engineer; H. C. Eddy, Public Utility Commission of New Jersey; Joseph Crawford, Supervisor of Transportation of the City of Newark; (Bottom Row) E. S Pardoe, of the Capital Traction Co. of the City of Washington; L. H. Palmer, of the Fifth Avenue Coach Co., New York City; and Henry G. McComb

16 to 18 hr. per day and operate between convenient division points, as between New York City and Pittsburgh, Pittsburgh and St. Louis, St. Louis and Kansas City, Kansas City and Denver, and Denver and Los Angeles. The 3340 miles from ocean to ocean is covered in a running time of 134 hr., or at an average speed of about 25 m.p.h. To maintain the advertised schedules is one of the most important factors in long-haul transportation.

Experience has shown that 75 to 80 per cent of the passengers prefer to go straight through to their destination without stopping at hotels at night, for reasons of economy, said Mr. Murdock in answer to a question. However, for the convenience of tourists, tickets are sold allowing 30 days to complete the trip. The company is working on the design of a motorcoach equipped with sleeping facilities, but so far finds that, if adequate accommodations are provided for each passeneger, only 12 passengers can be carried this would not pay unless a higher fare were charged to compensate for the small number.

F. C. Horner, of the General Motors Corp., stated his belief that there will be a genuine demand for motorcoaches completely equipped with berths and all facilities for night travel. He quoted from an English paper a description of such a service between Liverpool and London, and mentioned one such vehicle that already has been put into service on the Pacific Coast.

The Business of Transportation

Problems of Motor-Vehicle Application and of Fleet Superintendent Told by Banks and Blanchard

ATTENDANCE at the Wednesday afternoon session was somewhat larger and more representative than in the morning. It was evident that leading transportation executives from far and near were in attendance. After being called to the chair, J. F. Winchester announced an invitation to visit the local shop of the Public Service Corp. and then called on W. F. Banks, of the Motor Haulage Co., to present his paper on Applying the Motor-Vehicle to Business.

Mr. Banks said that, when motor-trucks first began to replace horse-drawn vehicles, their only recognized advantages were a greater load capacity and radius of action, but now they are recognized as a necessary adjunct of business. Barriers of distance have been pushed aside and speed is one of the chief requirements. Business has been enabled to expand and a great saving in labor has been effected.

After acknowledging the credit due to the manufacturers of vehicles, credit was given to commercial organizations that operate vehicles for their individual needs for the most consistent and stabilized developments in motor-vehicle application. Such organizations own 82 per cent of the commercial vehicles used in this Country and have resources for experimental work and facilities for determining costs. The strides of the ice-cream industry were cited as an example of great development that has been helped by the use of motor-trucks with modern facilities, such as dry ice and mechanically operating refrigerating units. Special body-equipment for packing houses was mentioned also. With overhead rails, six to seven tons of dressed beef can be loaded or unloaded by one man at the rate of one ton per minute. Traveling concrete-mixers, that deliver the material at the job ready to pour, also were mentioned. Many corporations have men whose entire time is devoted to the application of motor-vehicles.

Adaptable Vehicles Needed

Commercial operators have not the same opportunity to develop special adaptations of vehicles because the ve-

hicles must be available for a variety of uses. The commercial operator's problem is to adapt his fleet to the requirements of a multiplicity of customers.

Although operators of this class own only 18 per cent of the commercial vehicles in the Country, they are said to be leaders in "red ink" prosperity. In spite of abnormal competition from irresponsible operators, however, some commercial organizations are conducting well-established businesses on a profitable basis, because they can provide adequate service for less than the service would cost if operated by their customers. Mr. Banks gave a number of examples of foolish and inadequate cost-accounting methods among concerns whose haulage operations are incidental, and reported a trend among such organizations toward employing outside vehicles. He strongly upheld the efforts of the Society to develop an adequate accounting system for haulage operations.

Problems of street congestion and inadequate loading facilities and elevator service also were touched upon by Mr. Banks.

The Fleet Superintendent's Job

Donald Blanchard, editor of *Operation and Maintenance*, read the second paper of the session, which was entitled, The Real Job of the Motor-Vehicle Fleet Superintendent. In it were mentioned some of the problems that give such a broad scope to the superintendent's work, many of them not entirely of a technical nature.

Stress was laid upon the importance of keeping the mind open to accept useful new ideas and of being a leader in thought in regard to transportation problems. The superintendent who initiates improvements in his department will be recognized as a much more valuable man than one who accepts new ideas only when they are forced upon him by his superiors.

The theory that recognition automatically will follow the making of a "better mouse-trap" is more or less obsolete. Selling his department is a duty that the superintendent owes to himself and to his subordinates. Negative items about the department reach the management automatically, and the positive achievements should be emphasized to offset them. Departments to which service is rendered should be considered as customers, and any unreasonable demands should be met with the utmost possible tact.

The Maximum-Weight Problem

One of the items touched upon in the discussion was suggested by remarks in Mr. Banks' paper about limitation of truck weights. G. P. Anderson, of the Dodge-Graham organization, remarked that legislation must be made for the good of the greatest number, and it could hardly be practicable to make all roads suitable for the heaviest motor-trucks. M. C. Horine, of the International Motor Co., agreed that no type of road should be saddled on the public for the benefit of one class of users. He said that too much consideration has been given to the passenger-car and not enough to the truck. The operation of a large truck is not chiefly for the benefit of the operator, but to provide economical transportation to lower the living costs of all. A. W. Scarrett, of the International Harvester Co., called attention to the impossibility of using long six-wheel trucks in congested cities, particularly for excavations and other work of contractors.

Several examples of auxiliary equipment used in work of public-utility companies were given by Frederick Glynn, of the American Telephone & Telegraph

Co., who said that earth-borers will work even in Pittsburgh shale, in which holes cannot be dug by hand labor without blasting. The development in winches has been of great importance, and they should be used more by commercial truck operators. He also reported a machine, in which interest was shown by others, that pushes a steel "snake" through a duct under the street by power, much more rapidly than 3-ft. sections of jointed rod can be pushed through by hand.

Trailers not only avoid excessive wheel-load but sometimes result in economy in handling. As an example, Mr. Glynn mentioned trailers for cable reels which are loaded by lifting the tongue of the trailer in the air. Other adaptations have been made for carrying tile, telephone poles and other materials. Truck manufacturers were complimented on the reasonable cost of their vehicles.

Earth-borers were mentioned also by E. W. Jahn, of the Consolidated Gas, Electric Light & Power Co., of Baltimore, who said that on a job where the soil is sandy one heavy-duty truck with a power winch and collapsible air-feeder recently bored holes and set 50 poles in a single day.

Pumps were mentioned both by Mr. Glynn and Mr. Jahn. The former spoke of a type which can be attached to the front of a truck or other vehicle, and the latter reported more reliable service from pumps mounted on the running-board and driven from the power-take-off of the truck.

Relation of Manufacturers to Truck Use

According to F. C. Horner, of the General Motors Corp., truck manufacturers have made improvements during the last two or three years in the amount of attention given to the requirements of the user. Mr. Scarrett spoke of the careful watch he keeps on the complaint file and placed some blame on salesmen who do not insist on selling vehicles that are large enough for the jobs they are to do.

Cornelius Myers, of the Myers Lubricating Co., observed that the truck manufacturers are very much slower in adopting improvements than are the makers of passenger-cars. This was answered by A. J. Scaife, of the White Motor Co., who said that it is impossible for the maker of commercial vehicles to manufacture them at a profit with model changes as frequent as that would involve. The number of trucks of a given model that are sold in one year is not sufficient to warrant it. In addition, it is a serious matter for the fleet owner to have changes made too frequently in models.

Mr. Scaife also spoke of the advertising value of delivery vehicles for certain classes of retail merchants. For their advertising value, bodies often are much more expensive in design and finish than they would need to be for the mere job of transportation. It is not uncommon for a body in this class to cost twice as much as the chassis. Part of this cost is rightly charged to the same account as are the advertising signs on buildings and billboards.

Plaint of the Motor Haulers

Long-Standing Feeling Against Irresponsible Truckmen and Truck-Makers' Sales Policy Aired

As usually occurs at meetings of motor truckers, the goats were set apart from the sheep, and the goatherd-shepherds who minister to both were criticized, at the Motor Haulage Session on Wednesday night. This was a joint session of the Society with the Motor Truck Club of New Jersey, opened by F. C. Horner, chairman of the Transportation Meeting Committee of the Society, and presided over by H. F. Bacon, president of the Club. About 150 members and guests of the two organizations were in attendance.

George W. Daniels, of the United States Trucking Corp., of New York City, who, as the first speaker, told of methods of Getting and Holding Business for the Motor Truck, started the debate on the goats and the goatherds. Unbusinesslike and self-destructive competition by truckmen who do not know their costs and who get business by underbidding haulers who do know costs and make rates that will enable them to stay in the business, were assailed as the goats. Truck makers whose sales departments sell to such irresponsibles on disastrous time-payments and misleading statements of operating costs were the goatherds, who were criticized for contributing to destructive conditions that always have existed in the motor-trucking industry.

This theme was seized upon by discussers and aired at some length until they were assured by Alfred Reeves, general manager of the National Automobile Chamber of Commerce, the only other scheduled speaker, that the truck-manufacturing members of the Chamber will welcome and give full consideration to any proper presentation of the grievances of the haulers which proposes a line of action that will not involve the manufacturers with the Federal Trade Commission.

Speakers at the Business-of-Transportation Session

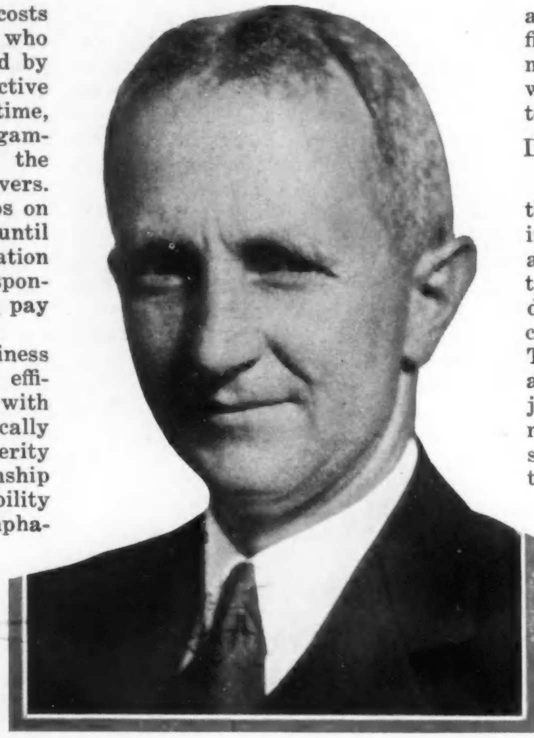
(Left) W. E. Banks, President of the Motor Haulage Co., Who Discussed Applying the Motor-Vehicle to Business, and (Right) Donald Blanchard, of *Operation & Maintenance*, Who Discussed the Real Job of a Motor-Vehicle Superintendent. J. F. Winchester Presided at the Session

Must Know Rates and Costs

Getting and holding business is the crux of the trucking industry, said Mr. Daniels in his opening remarks, for without business and the ability to hold it, trucks do not roll and then something breaks, generally the truck owner. To get business, the owner must know rates; to know rates he must know costs; to know costs he must be experienced; and, to be thoroughly seasoned, he must know, not only the practical side of truck operation, but the scientific side as well. Although this sounds platitudinous, continued Mr. Daniels, it is surprising how little some men, who claim to be practical truckmen, know about rates.

In many cases the subject of costs is like Latin and Greek to men who haul for hire. Business is secured by underbidding competitors irrespective of operating costs, so that, in time, the "wildcatter" or transportation gambler discovers that he has not the money to pay his rent and his drivers. He then skimps on service, perhaps on insurance, and on everything else, until the customer awakes to the realization that, to get real service from a responsible, capable operator, he has to pay for it.

The bulk of the trucking business must be solicited, and upon the efficiency of the solicitation, together with the submitting of rates scientifically arrived at, must depend the prosperity of the enterprise. While salesmanship is a prominent factor, service reliability and personal interest must be emphasized more than mere salesmanship, according to the speaker. Rash promises are to be avoided and, instead, the hauling needs of the customer should be studied and facts and figures submitted in accordance therewith. Wholesale solicitation by circular letters and the employment of solicitors on a commission basis were disapproved, as was also the soliciting of business from subordinates in concerns having trucking to do.



F. C. Horner
Chairman of the 1928 Transportation Meeting Committee

Summing up this phase of his subject, Mr. Daniels said: "You can best get new business by being sure of your rates, having the nerve to submit them and stick to them, suggesting ways and means by which the customer might save money in shipping, and by tenacity of purpose in attempting to get new business."

How to Hold Business

To hold business once secured, service was reiterated and emphasized as of prime importance; personal contact was mentioned again; prompt investigation and settlement of claims was stressed; courtesy of drivers and other employes and the employment of a dulcet-voiced telephone operator were urged. Mr. Daniels recommended care and promptness in submitting correct bills and statements, and promptness in getting the bills paid. In addition to these, it is vitally necessary to keep well posted on what is going on in the industry, on business in general, and on what competitors are doing.

College-trained young men have been entering the trucking business during the last 10 years, said Mr. Daniels, and their number will grow, because financiers are interested in cost per mile of operation and profit per mile, which many old-time truckmen cannot tell them.

Destructive Competition Debated

Most of the discussion centered on the strictures laid by Mr. Daniels on irresponsible and uninformed truckmen and on truck manufacturers who sell to them in what he regards as misdirected ways. J. F. Galvin, of Chicago, former president of the National Team & Truck Owners Association, agreed fully with the speaker and joined in the hope expressed by Chairman Bacon, that the Society will take steps to help overcome the selling of trucks to irresponsible haulers. C. S. Lyon, of the Heavy Haulage Shop & Garage Co., of Brooklyn, also expressed his accord with the previous speakers and said that only through frank and close cooperation and exchange of ideas by the legitimate haulers can the industry be placed on a businesslike basis.

Day Baker, representing the motor-truck operators' organization in Boston, told of the hardship worked on haulers by the State compulsory liability-insurance law and of the trend of department stores in the Hub toward hiring their delivery work done by common carriers.

Reeves Urges Cooperation

Organization and good-humored cooperation were strongly urged by Mr. Reeves, in a splendid address that concluded the session, as means for combating ruinous competition and unscientific restrictive legislation. Prefacing his talk on his assigned subject, How Cooperation Can Help Truck Owners, he said that all that the truck manufacturer wants, in return for doing the things the preceding speakers suggested, is that they will guarantee him a sufficient number of orders to keep his business growing, and, second, that the haulers will see to it that he will be kept out of jail if he attempts to do anything that savors of interference with interstate commerce or with rulings of

How the Meeting Scored in the Newark and New York City Newspapers

the Federal Trade Commission. It is a difficult problem; but if the haulers will effect a strong organization on sound fundamentals and make a presentation of their case that has merit, he said, the truck makers will be delighted to listen.

Mr. Reeves illustrated what the right kind of cooperation can do by citing examples of the cooperative work of the Chamber, all with a broad view of the interest of the motor-vehicle industry as a whole and with the object of broadening the market instead of restricting it for the benefit of a few companies. He commended the Society for its constructive work in holding the Transportation Meetings, in which the trucking interests are brought together. The big trucking companies are well able to take care of themselves. No one knows whether the small company that is making a start will grow big and creditable, but in this free Country he cannot be stopped; he is going to be given an opportunity to start, and if he does not conduct his business right he will pass out of the picture very quickly.

Referring to conditions that can be greatly improved by organizing and working closely together, Mr. Reeves said that a knowledge of costs is most important, so that the small operator will know what rates he should charge to make a fair profit. Standardization of traffic regulations is a problem, and unfair legislation must be watched and combated constantly. Compulsory insurance in some form must be expected. General education of the public and honest expenditure of money for highways are other matters needing cooperative action.

Six-Wheelers and Legislation

Economic Advantages of New-Type Truck and Why Legislators Should Favor It

HOW distribution of weight on six instead of four wheels makes possible the hauling of greater loads with less destructive effect on the highways was explained in a paper by Ethelbert Favary, consulting engineer of the Moreland Motor Truck Co., at the Thursday forenoon session. As the author did not come to the meeting from Los Angeles, his paper was summarized by Robert T. Hendrickson, sales manager of the Hendrickson Motor Truck Co., of Chicago. Mr. Favary's paper, which probably will be printed in full in a later issue of THE JOURNAL, also included references to legal restrictions in various States and countries on gross truck weights allowed and distribution of weights on axles.

Prepared discussion on these phases of the subject was presented by Thomas H. MacDonald, chief of the Bureau of Public Roads, and by Prof. A. H. Blanchard, highway transport and traffic-control consultant, of Chicago. Following these speakers, the subject was thrown open to general discussion by A. F. Masury, vice-president and chief engineer of the International Motor Co., who presided.

LAW MAKERS SHOULD TAKE NOTE

To illustrate the saving in transportation cost to both the truck user and the public which provides the funds for road construction, Mr. Favary contrasted the costs of hauling with 2½-ton four-wheel trucks over a cheap road and with a 5-ton four-wheel truck over a more expensive road. Pointing out that it would, however, be uneconomic to build roads to carry larger-capacity trucks of conventional design, because of the great mileage of secondary highways in the Country, he then listed 10 economic advantages of the six-wheel truck of balanced rear-axle design and explained these seriatim. Among the advantages claimed as regards preservation and use of the roads were reduced loads on each wheel, reduced road-impact forces, reduced tendency to wheel-spinning and tire-sliding, less road congestion, greater safety and reduced skidding. Results of tests made by the Bureau of Public Roads were given to support the claims of lessened roadbed pressures and road impacts. Emphasis was laid on the point that stress produced in the pavement is a function of the load on the wheels and not of the spacing of the axles, provided the spacing of the rear axles is greater than 3 ft. The author con-

THE CHAIRMAN AND SPEAKERS AT THE SIX-WHEEL SYMPOSIUM

(Left) Robert T. Hendrickson, of the Hendrickson Motor Truck Co., Who Presented E. Favary's Paper on Highway Legislation and the Six-Wheel Truck; A. F. Masury, of the International Motor Co., Who Maintained Law and Order; and T. H. MacDonald, Chief of the Bureau of Public Roads, Who Discussed the Effects of Six-Wheel Vehicles on the Highway

tended that, to obtain proper balancing effect of the rear axles, the distance between them should be from 40 to 48 in.

The California motor-vehicle act of 1923, limiting gross weight on four wheels to 22,000 lb. and on six wheels to 34,000 lb., was cited, and subsequent recommendations of the Supervisors Association of California supporting these limitations were quoted. In conclusion, Mr. Favary mentioned that 11 States have enacted laws distinctly specifying a greater load on six wheels than on four, and that several others merely limit the load per axle or per wheel, thus by implication favoring six-wheel vehicles. Legislators, he held, would be benefiting their States by enacting laws allowing greater loads on six-wheelers than on four-wheel vehicles through specifying maximum axle or wheel weights. The laws should also specify that the two rear axles should be not more than 4 ft. apart and that a balanced suspension be used. Finally, he asserted that six-wheel vehicles equipped with proper brakes are as safe as any vehicles and should be permitted to operate at as high speeds.

Engineering Points Discussed

Motion pictures were shown by Mr. Hendrickson following his summary of the Favary paper. These showed the flexibility of the six-wheel truck in operating over very rough going and the easy riding of the heavy load. By way of contrast, pictures of four-wheel trucks carrying their loads over the same rough roads were shown. Various technical questions regarding the construction, the sprung and unsprung weight, the differential system, and the claim for superior traction were raised by President W. G. Wall, Chairman Masury and A. J. Scaife, and were answered by Mr. Hendrickson and illustrated with blackboard drawings. Nathan Cherniack, analyst of the Port of New York Authority, called attention to the time lost in loading and discharging 10-ton as against 5-ton loads as an economic factor, and inquired if the six-wheel truck is adaptable to hauling freight in and around cities in competition with tractors and semi-trailers. In reply, Mr. Hendrickson observed that "the six-wheel truck is simply a refinement of the tractor and trailer, with all their advantages and none of their disadvantages." He conceded that there is a field for the tractor and trailer in short hauls and where the loading and unloading time is considerable.

Facts of Import to Public

Professor Blanchard dealt with the subject entirely from the highway angle. He said that Mr. Favary's paper bristles with conclusions of the utmost value to the public and hoped that wide publicity would be given to the subject

through the general press. He deprecated the tendency to call even concrete roads permanent or to say that any pavement will last indefinitely if vehicle loads do not exceed a certain limit. In this Country we have the problem of building great mileages of roads in the shortest possible time to carry the necessary traffic, but the importance was emphasized of giving heed to lessons learned by engineers in European countries that have had centuries of experience. He cited reports of committees of the American Road Builders Association and the American Society of Civil Engineers advocating that bridges on main highways be constructed for loads of 40,000 lb., those on secondary roads for 30,000 lb., and those on third-class roads for 26,000 lb.

Relation of Vehicle and Load

Mr. MacDonald, in his prepared discussion, divided the subject into its physical and its economic phases. He pointed out that, just as the vehicle affects the road, the road affects the vehicle, hence there must be a mutual relationship from which each must profit or suffer. For real economy, there must be mutual adjustment. This precludes uneconomic restrictions upon the size, weight and speed of the vehicle, and as surely excludes undue size, weight and speed on the road. Two general conclusions that may be fairly drawn are that (*a*) the six-wheel vehicle offers a desirable and effective answer to the problem of the load above the normal desirable limit for the four-wheel truck, and (*b*) it offers a similar answer to the problem of the load equal to the heavier four-wheel truck in areas where road conditions do not permit maximum weight concentration. He quoted half a dozen conclusions from tests made by the Bureau of Public Roads, to the effect that (*a*) deflection of a concrete pavement is directly proportional to the load applied, (*b*) a load 9 in. from the edge of a pavement of 6 in. uniform thickness produced approximately twice the fiber deformation in the edge as was caused by the same load at 21 in. from the edge, (*c*) tension produced in the top of the pavement due to counter-flexure between the wheels of a six-wheel vehicle is less than the tension produced in the bottom of the pavement directly under one wheel regardless of axle spacing, (*d*) the tension produced seems to be a function of the wheel load and not of the axle spacing, (*e*) fiber deformation is directly proportional to the load, and (*f*) maximum deformation occurs along the edge of the slab for both four-wheel and six-wheel vehicles.

Six-Wheel Trucks a Solution

Mr. MacDonald also mentioned the impact researches of the Bureau, in which the Society has cooperated, which indicate that the unsprung component of the impact reaction of the six-wheel vehicle is about one-half that of the same weight of a four-wheel vehicle.

In conclusion he stated that surveys have shown that, except for certain restricted industrial districts and arterial roads connecting them, the 5-ton truck is the largest selected for general use. He suggested a weight limitation of 8000 lb. per wheel for general use on improved roads, 9000 lb. for terminal areas and roads connecting them, and, for municipalities, the limits prescribed by ordinance. Other factors than wheel load influencing road design apply to all trucks in common. On low-type roads in many parts of the Country the load capacity is affected by weather conditions. Here the solution of the problem is limitation of wheel-load concentration by permitting use of six-wheel trucks equipped with pneumatic tires.

Committee Reports Presented

Present Status and Future Plans for Operation and Maintenance Committee Work

Reports of the Operation and Maintenance Committee and its Subcommittees occupied the attention of the members and guests at the session held Thursday afternoon, Oct. 18. R. E. Plimpton, Chairman of the Committee, presided, and, following his presentation of the Committee's report, the chairmen of the several Subcommittees read their reports and replied to questions asked during the time allotted for discussion of each report.

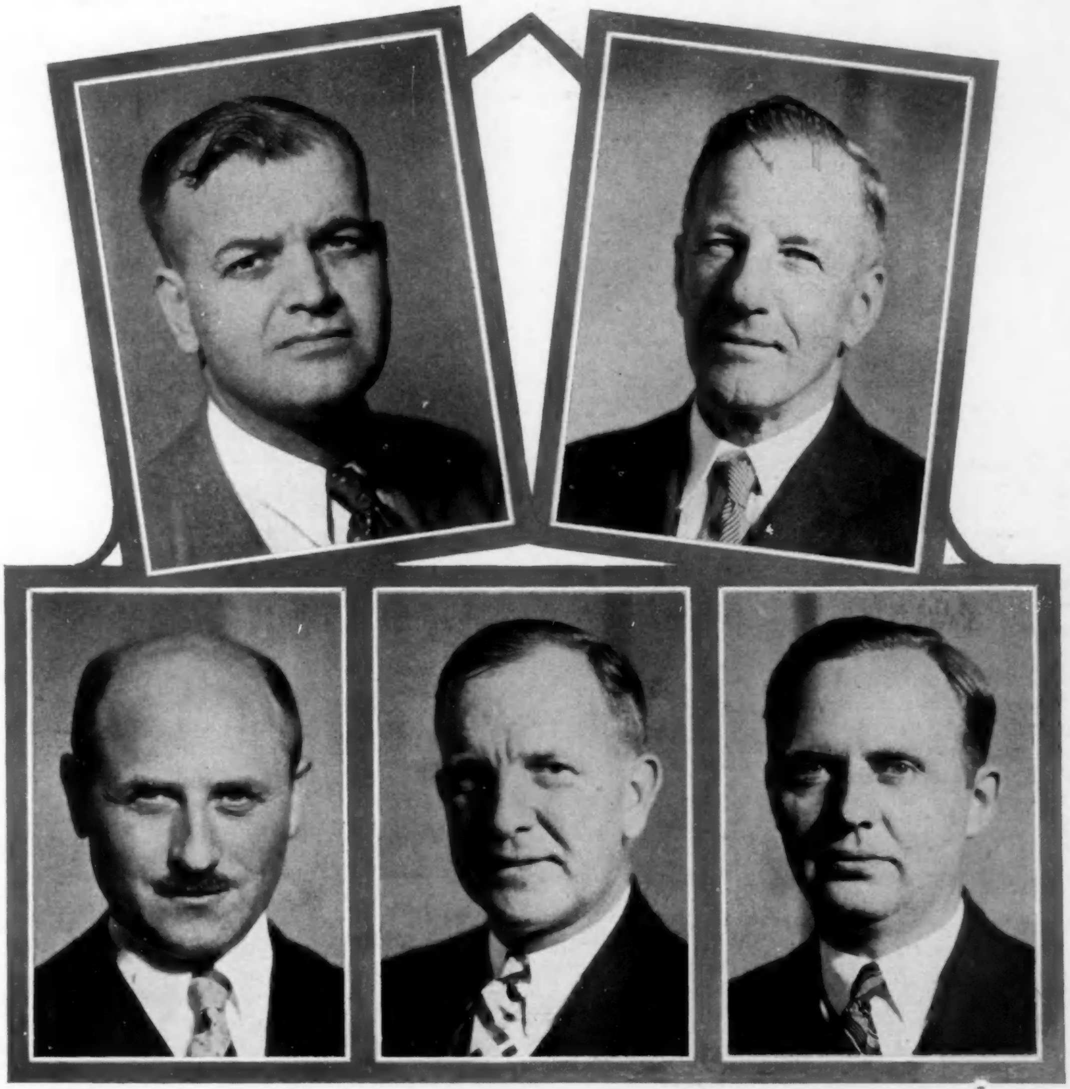
In presenting his report as Chairman of the Operation and Maintenance Committee, Mr. Plimpton referred first to the subject of standardization, which, in his opinion, now has a broader scope than formerly when it referred

mainly to design and construction. For example, the report of Subcommittee No. 1, referred to later and covering the matter of mechanical information, constitutes the beginning of a standard that is likely to be put into practice in the same manner that applies to standards of design. Therefore, the Committee inquires in its report as to what the future means should be for carrying on this phase of the work; that is, whether there should be closer contact with the present Standards Committee or some separate way of handling the matter.

Tie-In With Other Committees

It was decided after discussion that it would be desirable to have an Operation Division of the Standards Committee, although this is, of course, subject to the judgment of the Council. After the establishment of such a division, however, any standards of particular interest should be cleared directly or in an advisory way through the division. It was further stated that, after the standards have been put through the proper procedure and submitted to the membership and voted upon, they should be published in some permanent form; for example, in the present S.A.E. Handbook.

In regard to research and the work of the Research Department of the Society, Mr. Plimpton said that the department's work necessarily has been largely for the benefit of the engineers engaged in design and construction, but that, for the future, it is hoped the department can give more attention to the needs of the operation and maintenance field. An important field which might be covered by the Research Committee through the Research Department was discussed at the Transportation Meeting held in Chicago in 1927; that is, a comprehensive research on highway transportation. The plan of having some outside person study the fundamentals was presented to the Council and was referred back to the Committee for definite suggestions. The Committee has since conferred with various universities in an effort to keep the matter alive, but has not determined upon any way of accomplishing the work, mainly because of the expense involved. However, the Committee believes it might be helpful to all members concerned with operation and maintenance if this work can be started even in a small



SEVERAL OF THOSE RESPONSIBLE FOR THE SUCCESS OF THE MEETING

(Upper Left) C. J. Fagg, Manager of the Newark Commerce and Trade Bureau; (Upper Right) C. E. Holgate, Manager of the Newark Automobile Trade Association

(Lower Row, Left to Right) Ole Singstad, Chief Engineer of the Holland Tunnel, Who Made Possible the Inspection of the Plant and Tunnel; E. F. Lowe, Chairman of the Reception Committee; E. F. Loomis, Secretary of the Motor Truck Committee of the National Automobile Chamber of Commerce

way. It was further stated that the Committee believes it desirable that the best papers on operation and maintenance subjects that are presented at the various meetings of the Society should be included in TRANSACTIONS in addition to publication in THE JOURNAL.

A PROFESSIONAL DIVISION FAVORED

Concerning the prospective reorganization of the Society referred to in the October issue of THE JOURNAL on p. 410, Mr. Plimpton said that the suggestion that there should be a group known as the professional division seems to meet with general approval. The question now is regarding the details of how the division should function and how fast the changes should take effect. Some of the changes proposed can be made without any Constitutional amendments; others that involve changes in title or in membership on the Council will require amendments. But, whatever is done, he said, the members interested in operation and in maintenance are sure to be well represented and will be given an opportunity to serve the Society and themselves in a larger way than in the past.

After presentation of the report of the Committee by Chairman Plimpton, reports from the various Subcommittees were presented and discussed. They are in the nature of progress reports and it is expected that the activities of the Subcommittees will be continued along the lines of the subjects assigned, so that the work on these several subjects can be brought to a definite conclusion by succeeding Subcommittees the personnel of which, enlarged if necessary, is suited to prosecute the work successfully.

CHASSIS MECHANICAL-RECORD FORMS

The report of Subcommittee No. 1, on the subject of providing and using suitable chassis mechanical-record forms, was presented by Chairman J. F. Winchester, of the Standard Oil Co. of New Jersey. This report is based upon the article by Mr. Winchester which appeared in the July issue of THE JOURNAL, p. 120, accompanied by a so-called Final Chassis Record Form which was suggested to promote discussion among members interested in the subject. Replies received to requests for suggested improvements in this form were analyzed by Mr. Winchester, who said that distinct progress in the matter has been made, and that he believes it is a question of the proper procedure within the Society itself as to how the Final Chassis Record can be formally adopted as another S. A. E. Standard.

The questions to be decided are, as stated by Mr. Winchester: Should the work be carried on by the Operation and Maintenance Committee as a unit; should it be carried on by the Standards Department; or should a committee be appointed to act as a representative of each group, so that, when the work is completed, it can be submitted and adopted as a standard?

EFFECT OF ACCESSORIES ON MAINTENANCE

Reporting on the activities of Subcommittee No. 2, the Effect of Accessories Such as Air-Cleaners and Air-Filters on Maintenance Costs, Chairman E. C. Wood said in part that the object of the Subcommittee work was to try to present the problems of the large and the small-scale fleet-operators with regard to air-cleaners and oil-filters, which are important factors in many sections in lowering the cost of vehicle maintenance. Data were obtained from answers to questionnaires sent to centrally located fleet owners and to owners of isolated units. Mr. Wood therefore explained the conditions that prevail in the different sections and read abstracts from various replies received, illustrating his report with lantern slides showing average climatic conditions and curves resulting from tests made of air-cleaners and oil-filters in service. In conclusion he said that, analyzing the subject from an economic viewpoint, such accessories as may be installed on motor-vehicles must be satisfactory as to construction and must decrease the number of man-hours required for maintenance.

R. E. PLIMPTON

Chairman of the Operation and Maintenance Committee, Who Presided at the Operation and Maintenance Committee Session

SELECTION AND TRAINING OF MECHANICS

The work of Subcommittee No. 3 on the selection and training of motor-vehicle mechanics was reported upon by F. L. Jacobus, of the Brooklyn Edison Co., in the absence of Chairman T. L. Preble. The report states in part that lack of enough competent mechanics has handicapped the motor-vehicle repair-business from the start, and that the situation has grown steadily worse because the number of motor-vehicles in use has increased faster than men have been trained for the work.

After outlining in its report the qualifications governing the selection of men, the Subcommittee recommends serious consideration by the Society of the project of developing a standard course of training for mechanics. The objective is to secure greater uniformity in the output of men, so that those who hire graduates can know more certainly what to expect of them and what further training they need. To this end it is suggested that, if the Society should decide to develop a standard course, the course worked out in 1924 by the National Automobile Chamber of Commerce be used as a basis and developed to meet present needs. This course was then explained by H. R. Cobleigh, of that organization.

MAN-POWER REQUIRED PER VEHICLE

The report of Subcommittee No. 4 deals with the man-power required per vehicle operated and with seasonal fluctuation of labor requirements. It was presented by Chairman F. C. Horner and is printed in full in the Operation and Maintenance Department of this issue, beginning on p. 512.

SELECTION AND TRAINING OF DRIVERS

The subjects covered in the report of Subcommittee No. 5, of which Ethelbert Favary is chairman, are the selection, training and payment of motor-vehicle drivers, and operating safety measures. In the absence of Mr. Favary, the report was read by Donald Blanchard, editor of *Operation and Maintenance*.

The report states that it is felt that the measure of success in the selecting, training and handling of drivers, as well as in the operating safety measures, is the labor turnover. Experience has shown that the greatest turnover usually occurs during the first three months of employment, which seems to indicate that the men selected either have not the proper qualifications or are not of the proper type for the work. Wherever the turnover is low, accidents are fewer in number. Increased turnover usually means a greater number of accidents. It seems that the most profitable committee work to be done on this subject is to study the best methods, or to devise new methods, for the selection of drivers. This should include the difference between the types of men required for several classes of service and the best methods for determining during their selection whether they will make satisfactory

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drivers. The more thorough and satisfactory the selection is, the smaller will be the labor turnover, the more efficient the work rendered by the men and the smaller the number of accidents.

Administration Systems and Methods

An outline of the report for Subcommittee No. 7 was read by Mr. Plimpton, as Chairman L. V. Newton was unable to be present. This report states in part that correct accounting of motor-vehicle expense is necessary properly to control motor-vehicle operation. Without operating costs, the truck operator is working in the dark and does not know what he is doing. He can only guess that he is right. Proper cost-accounting methods, if used, will result in a reduction in operating costs after a reasonable period, as the operator will be enabled to improve his costs by intelligent operation.

It is recommended by the Subcommittee that all costs be kept by individual vehicles. While to some this may seem unduly laborious and expensive, it is felt that the results obtained will justify the expense incurred. Only by knowing the exact cost of operating each vehicle can the most economical and efficient unit be determined and the operator be in position to know exactly what he is doing. This can be done conveniently by assigning a number to each vehicle. The numbers may be assigned to classes of vehicle by series, so that the number will indicate the type of vehicle; or they may be assigned in rotation as the vehicles are acquired.

Submission of a uniform classification of accounts does not necessarily mean that, to follow this classification, the accounts must be kept as set forth. It is recognized that companies are keeping their accounts in accordance with accounting orders of regulatory bodies, and that the classification of accounts used in accordance with such orders may not permit all charges to be made as outlined in the report. This, however, will not prevent the assembling of the information necessary to prepare the suggested costs.

Tabular classifications and analyses accompany this report, and it is expected that the report will be printed in full in an early issue of The Journal.

Valuable discussion was contributed during the progress of the session on the important questions raised by the reports as presented, and it is planned to print this discussion in a later issue of The Journal in conjunction with the report to which it applies.

Traffic Discussed at Banquet

McClintock Chief Speaker—Other Talks by Horner, Van Riper, Bittles, Dresser, Plimpton and Wall

Nearly 300 Society members and other guests, assembled in the ballroom of the Robert Treat on the evening of Thursday, Oct. 18, participated in the Transportation Banquet, which was one of the most enjoyable social functions ever staged by the Society. Flowers and shaded lights helped to make the ballroom a most attractive scene, and the guests upon reaching their tables found at each place a handy and useful little memorandum book, a gift from the Standard Oil Co., through the courtesy of J. F. Winchester.

Chairman F. C. Horner, of the Transportation Meeting Committee, wielded his gavel and gained the attention of the audience while he announced that Jolly Bill Steinke, well-known cartoonist, would entertain them with some sketches. Time passed rapidly during the next half-hour while Jolly Bill, of the skilful hand and infectious chuckle, made sketches of everyone at the speakers' table, keeping up a constant fire of questions, comments and wisecracks throughout his performance. Some of the cartoons appear on this page and elsewhere in this issue.

Beginning with Mr. Winchester, superintendent of motor equipment for the Standard Oil Co. of New Jersey, who was at one end of the speakers' table, and omitting only Mr. Horner, Mr. Steinke sketched the following:

T. H. MacDonald, chief of the Bureau of Public Roads; T. J. Wasser, county engineer of Hudson County, New Jersey; W. L. Mallon, president of the Newark Automobile Trade Association; H. F. Bacon, president of the Motor Truck Club of New Jersey; Harry F. Miller, treasurer of Thomas A. Edison, Inc., representing Mr. Edison; William Bittles, president of the Newark Chamber of Commerce; Dr. Miller McClintock, professor, Harvard University; Judge Walter Van Riper of the New Jersey District Court; Col. W. G. Wall, president of the Society; R. E. Plimpton, associate editor of *Bus Transportation* and Chairman of the Operation and Maintenance Committee; S. R. Dresser, chief cable engineer of the Whitney Blake Co. and Chairman of the Metropolitan Section; Ole Singstad, chief engineer of the Holland Tunnel, New York State Bridge and Tunnel Commission; and E. C. Wood, of San Francisco, Vice-Chairman of the Operation and Maintenance Committee.

Then, not to slight Chairman Horner, Jolly Bill had him pose, gavel in hand, and, when the sketch was completed, the cartoonist announced that his part in the program was finished and that Mr. Horner could carry on from that point; whereupon Mr. Horner, bringing the gavel down upon the table, called the meeting to order and introduced the toastmaster, Judge Van Riper.

Judge a Genial Toastmaster

If any apprehensive souls in the audience feared that a judge would be either ponderous in his remarks or formidable in his manner, Toastmaster Van Riper quickly dispelled such fears and put everyone at ease with several appropriate anecdotes, leading up to his introduction of Mr. Bittles.

After welcoming the Society's members and guests on behalf of the citizens of Newark, Mr. Bittles touched briefly upon the subject of transportation, with special reference to Newark's transportation problem, as he outlined present remedies and future plans for its solution.

Mr. Dresser, the next speaker, extended a cordial welcome on behalf of

the Metropolitan Section, as Newark, the site of the Transportation Meeting, is in its territory. Speaking of the rapid march of progress, and stating that never before has the need been so acute to use every available means to keep up with the procession, Mr. Dresser urged the desirability of attendance at S.A.E. Section meetings and invited all present to participate in the activities of the Metropolitan Section.

R. E. Plimpton expressed the opinion that the work of the Operation and Maintenance Committee would continue to grow as a valuable part of the Society's Transportation Meetings and stated that the Committee would welcome suggestions for the improvement of this work.

President Wall Discusses Essentials

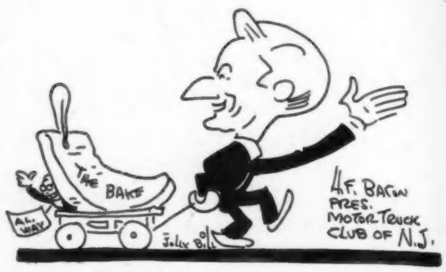
President Wall, who was the next speaker, said that transportation always has been man's greatest problem and that the successful transportation of people means moving the greatest number at the least cost in the shortest time and in the most comfortable way. He regards cost as the most important of these factors, with speed the next in importance. Outlining in a few words the part that improved vehicle design and improved roads have played in the betterment of transportation facilities, Colonel Wall spoke briefly on the importance of the traffic problem. He pointed out that, as all motor-vehicles have to be operated and serviced, there is no question that, as time goes on, operation and maintenance will become the largest part of the industry and those engaged in this branch will be the dominant factor in the vehicle world. In conclusion, he spoke of the need for an Operation and Maintenance Division in the Society and dwelt upon the desire to meet the needs of all members of the Society.

McClintock's Talk a Winner

Toastmaster Van Riper then introduced, as the chief speaker of the evening, Dr. Miller McClintock, professor of traffic research of Harvard University and director of the Albert Russel Erskine Bureau of Street Traffic Research.

Outlining the reason for the modern traffic problem, Dr. McClintock showed that it rests upon the fact that motor vehicle designers and manufacturers have built into motor-vehicles potentials that cannot be utilized under present street and highway conditions, and said that this fact results in economic loss to the operator and the community and in a handicap to the motor-vehicle industry. Although offering no simple formula to solve the problem, he discussed various methods of relief. Dr. McClintock's speech is printed in full on p. 443 of this issue of THE JOURNAL.

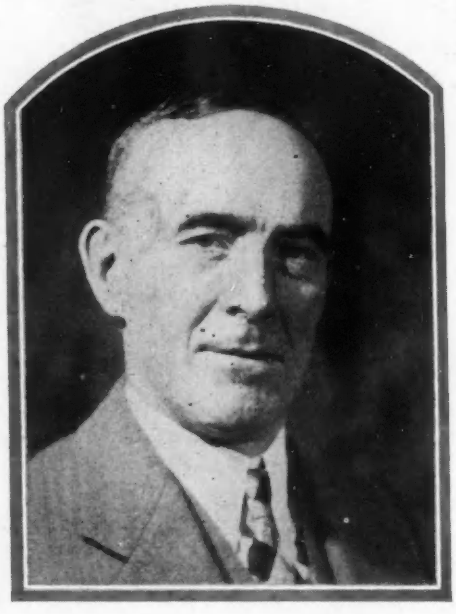
Dr. McClintock spoke with a fluency that not uncommonly belongs to a man who knows his subject thoroughly and is actuated by an intense desire to interest his hearers in it. The appeal made by the timeliness of his remarks and the effectiveness of his presentation was evident in the close attention accorded him by his entire audience. Upon the completion of Dr. McClintock's speech, Toastmaster Van Riper declared the banquet adjourned.



Store-Door-Delivery Question

Canada's Long-Successful System Described in Detail and Its Application Here Debated

IS store-door delivery of less-carload railroad freight, as it has been practised successfully in Canada since the early days of the railroads, feasible in American cities?



R. A. C. HENRY

Director of Bureau of Economics of the Canadian National Railways, Who Described Canadian Store-Door Delivery

This question was debated by men who are familiar with railroad and haulage conditions in New York, Boston and other cities, at the Friday forenoon session after listening with great interest to an excellent detailed description of the Canadian system, which was presented by R. A. C. Henry, of the Canadian National Railways. F. C. Horner presided as chairman.

Mr. Henry, in sketching the history of the development of the system in Canada, showed that it was an extension of contract cartage that has existed in England for more than a century. As the earliest construction of railroads in Canada was financed by English capitalists, it was natural that the early practice of the British railroads in contracting for freight delivery by the former van operators should be adopted. Consequently, the Great Western Railway made such arrangements in 1855 with a firm of young carters for collection and delivery of railroad freight in Toronto, Hamilton and London. The following year the Grand Trunk Railway effected similar arrangements with the same carters for Montreal, Toronto, Brantford and Guelph. The Canadian Pacific and the Canadian Northern Railways early organized subsidiary cartage companies to perform store-door delivery for them.

Canadian-National Cartage Operations

Referring specifically to the Canadian National Railways, of which the Grand Trunk and Canadian Northern became parts of the system, Mr. Henry stated that store-door delivery is now in effect on the system in the Provinces of Quebec, Ontario, Manitoba, Saskatchewan, Alberta and British Columbia in 22 cities having a combined population of 2,855,000.

Lantern slides were shown of the railroad terminals in Toronto, and Mr. Henry described the method of freight movement between railroad cars and road vans. Percentages of the total l.c.l. freight handled on the Canadian National Railways by this system were given as 64 per cent in Montreal and 63 per cent in Toronto and Hamilton. In Montreal 19.8 per cent of the 1660

(*Continued on p.* 520)

Chronicle and Comment

All Sections, Please Note!

TWO important matters must receive the attention of every Section before the end of 1928. One concerns the election of a representative from each Section to serve on the 1929 Sections Committee; the other relates to the election by each Section of a representative and an alternate, to serve on the Society's Nominating Committee. The regulation governing the former is found in Article C45 of the Society's Constitution; that governing the latter is found in C46 of the same document.

These two elections must be held at either the November or the December meeting of each Section, preferably in November.

The Chicago Aeronautic Meeting

IT has been found necessary by the Aeronautic Meeting Committee to schedule three National Aeronautic Meetings this year, to meet the need for discussion of technical aeronautic problems. The first meeting was held in Los Angeles on Sept. 11 and 12; the second meeting will be held in Chicago on Dec. 5 and 6, and the third will be held in New York City on Jan. 7.

Chicago's two-day meeting will be at the Hotel Stevens at the time of the International Aircraft Exposition, which is sponsored by the Aeronautical Chamber of Commerce of America. The technical sessions are to be held with the cooperation of the Chamber.

Of special interest in connection with the Chicago meeting is the joint conference on aeronautical standardization of the S.A.E. Aeronautic Division and the Commercial Manufacturers' Section of the Chamber. As the Aeronautical Chamber of Commerce relies upon the Society to deal with its technical problems, the conference should produce results of inestimable value to the aircraft manufacturers.

A Fellowship for Research Work

INDUSTRY has come to the conclusion, during the last decade, that advertising alone will not sell its products; the desire for a better and cheaper product must be answered. However, development has reached a stage at which further improvement can be made only after research into the fundamental underlying principles of those products. Pure knowledge must precede practical invention. This realization has resulted in a great demand for research workers and the complaint that the number of persons properly trained and equipped to fill the need is insufficient.

On the other hand, a number of colleges throughout the Country have well-equipped laboratories and men with natural ability and the inclination to do research work; but the indications are that, in general, both the men and the facilities available for this work are being utilized very inadequately, to the detriment of both industry and education. It remains for the colleges to offer the type of training that will bear a practical relation to this need in industry. We are therefore glad to give space to such an offer from the Pennsylvania State College of a ten-month fellowship of $800 in the Engineering Experiment Station that leads to a degree of Master of Science.

Young men who have recently taken a bachelor's degree and are interested in the fellowship offered can secure further information from Prof. F. G. Hechler, Pennsylvania State College, State College, Pa.

The S.A.E. Handbook Supplement

ATTENTION is called to the publishing of the Supplement to the 1928 Edition of the S.A.E. HANDBOOK, which has just been mailed to members. This is the first time that the new and revised specifications approved by the Standards Committee at the Summer Meeting has been issued in this form, which is in keeping with the policy adopted by the Council of publishing the HANDBOOK once a year.

The Supplement is trimmed to permit insertion in the back of the HANDBOOK and contains a list of the pages in the bound volume which are superseded by the revised specifications contained in the Supplement. The 1929 edition of the HANDBOOK, to be published about March 15, will contain all the revised and new specifications now in the Supplement, and also the Standards and Recommended Practices approved and revised by the Standards Committee next January.

Members who have not received their Supplements should notify the Society so that lost copies will be traced or replaced.

The Transportation Meeting

THE record attendance of 460 at the Newark Transportation Meeting emphasizes the increasing importance of fleet operation and maintenance activities in the Society. The attendance record of the Transportation Meetings, inaugurated in 1921, makes this increase in interest still more striking. These figures are for meetings devoted entirely or largely to fleet operation and maintenance, the attendance at service meetings not being included:

1921 Chicago	130	1926 Boston	394
1923 Cleveland	175	1927 Chicago	303
1924 New York City	212	1928 Newark	460
1925 Philadelphia	326		

The greater activity is indicative of the growth of the operation and maintenance work in the Country and of the increase in the number of Society members engaged in this activity. The membership of several of the 13 Sections is composed almost entirely of operation and maintenance engineers, and the meetings of these Sections are devoted to such subjects of special interest to them. In the light of the figures given, the growing interest in the professional-division idea is easily understandable. It is planned to hold special meetings of the Standards Committee and special business meetings of the Society during future Transportation Meetings to pass upon proposed S.A.E. standards and recommended practices and upon committee reports pertaining to operation and maintenance. This will obviate the need for holding such reports until the Annual or the Semi-Annual Meeting.

Dr. Miller McClintock

Remedies for Traffic Congestion

By Dr. Miller McClintock[1]

Transportation Meeting Dinner Address

IT is not without a very important and fundamental significance in American life that in a quarter of a century we have developed 25,000,000 automotive vehicles that are operating over our streets and highways. The advent of the motor-car in such tremendous numbers and, indeed, with such perfection today, has broken down State and county lines; it has welded the Nation together as no other instrumentality has ever welded it together; it has speeded up the whole temper of industry and commerce. What is more, it has given the individual citizen of the United States an entirely new relation to his environment. It has set up for him new and much more profitable standards of time and distance.

This Country, if founded on any single principle, was founded on the principle of freedom—freedom of individual speech, freedom of individual religious opinion, and freedom of the press. Now the automobile has brought something which is an integral part of the American spirit—freedom of movement. It has kept citizens from vegetating; it has changed the individual from a 30-mile-a-day to a 300-mile-a-day man and put at his control flexible agencies of transportation, even individual transportation, that are within reach of any citizen.

These are substantial contributions to American life. Unfortunately, this change has come under conditions such that the introduction of the automotive vehicle has brought in its wake, not only benefits, but serious and aggravated problems. I want to outline briefly what the traffic problem is at present.

If no vehicle could move more than 5 m.p.h. nor could carry more than 5 tons, we should be conscious of no traffic problem today. The traffic and traffic-congestion problem is not a condition which we see upon our highways, it is an attitude of mind. If none of our vehicles could move at a greater speed than 5 m.p.h., we should all be satisfied with the speed of movement we can find upon the streets today. If none of them could carry more than 5 tons economically or if no one could design vehicles to carry more than 5 tons, no question would exist of restrictive legislation regarding weights and other limitations that are so troublesome in the transportation business.

Dr. McClintock, who probably is the foremost authority in America on highway traffic and on means for expediting and directing its movements, tells herein how motor-vehicle operators can take definite steps to save themselves, their communities and the Nation heavy losses.

Motor-vehicles are not being operated at more than 20 per cent of their potential efficiency, he asserts, because the automotive vehicle was brought suddenly into a horse-and-wagon age. Physical conditions that reduce the capacity of streets and highways and hold down the speed of vehicles must inevitably be changed. Construction of elevated highways and the separation of grades have already begun in several cities.

Truck and motorcoach operators have it in their own power, through both individual and collective action, to relieve congestion and to perform their service as carriers more promptly and economically by ways which the author specifies.

The direction and regulation of traffic are engineering functions. Within the last six years 12 of the largest cities in the Country have established traffic-control engineering agencies.

We have a traffic problem today because you and your colleagues have built into automotive vehicles potentialities that we cannot possibly use under present street and highway conditions. A man said to me this evening that the automobile engine is theoretically only 20 per cent efficient. I submit that the average motor-car operating over the streets of our typical American cities today is not using more than 20 per cent of even that potentiality which it has. That is why we have a traffic problem; the conditions under which those vehicles must operate hamper their operation. Vehicles capable of carrying 5 to 10 tons at efficient speeds up to 30 m.p.h. are forced to drag along in traffic with long delays and at an average speed often as low as 3 m.p.h. It has been estimated that these wastes amount to $1,000,000,000 per year in the United States. Not only that, but the operating conditions are dangerous as well, resulting in a loss of life of 27,500 persons in the continental United States last year.

This is a problem of vast importance, for you are operating transportation agencies the capability of which cannot be utilized under present traffic conditions. This means economic loss to the operators and to the community, and a handicap to the industry served. Moreover, these losses are irreparable. Not only are they losses to the community in current operations, but the present congestion upon our streets and highways is a tremendous handicap to the automobile industry.

We have heard a great deal about the saturation point, the time when the American public will have absorbed all the automobiles it can absorb. At no time in the last three years has that saturation point been controlled by the financial ability of the American people to *buy* the automobile; it has been controlled by the ability or the inability of the people to *use* the automobile. So long as these conditions continue, we shall

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find it difficult to induce more of the population to absorb individual cars and, to a degree you well recognize in your own communities, to use the automotive transportation services that are being provided for passenger transportation.

Solution Demands Changed Psychology

Solution of this problem will necessitate a radical change, not only in technical engineering attitudes, but in public psychology. The automobile was dropped into a horse-and-wagon age. I am ashamed to have to say that many of our governmental jurisdictions, and indeed some of our engineers, still act as though they were living with whip-sockets and dashboards and hitching-posts.

I wish I could say that Harvard University has discovered a simple, financially possible and economical formula whereby this great loss of life and profits on our streets and highways can be eliminated. No such simple formula exists, because the problem is one of the greatest complexity.

There are two classes of relief for this. The first is to be found in a radical improvement in the physical characteristics of our street plans and in those physical appurtenances and attachments which, with the streets, make a complete physical layout for the complete operation of motor-vehicles. If in your researches you discover a new way to design an internal-combustion engine that is much more efficient than any you have used before, I dare say that you would discard, if necessary, all of the patterns and designs for the chassis and all the equipment for the vehicles you are building, and construct an entirely new unit to use this agency to its greatest capacity.

Similiarly, we shall have to change the horse-and-buggy street system substantially. The changes will involve some assistance on the part of motor-vehicle operators. The builders of automobiles and those who have maintained them have gone about as far as we can expect them to go in adapting their agencies to existing conditions, although we can expect some further improvements, such as better brakes, perhaps, and better acceleration. But one thing is certain, a person or a pound of goods cannot be got into a place that is more than just so small. The vehicles cannot be made very much smaller than they are, if they are to maintain their efficiency; so we cannot expect a great deal more assistance along that line.

Any community in the United States which is not at present alert to the need of widening its streets where it can and needs to widen them, of extending them where they need to be extended, and of maintaining them with good pavements, is overlooking a fundamental and a minimum service which it ought to be performing for the transportation of commodities and persons. If the cities are not doing their city-planning work as they should be doing it, they are far behind the times.

Ways To Increase Street Capacity

The need of one type of improvement is very obvious. Since our streets, as they now exist, are inflexible in their width and capacity, because the more important ones which most need attention have been lined with costly and important structures the demolition of which would be financially impossible, it is necessary to free those arteries of travel from obstructions of every kind that are not essential to the movement of persons and commodities over them.

It is necessary, in all the great metropolitan centers, to transfer into off-street facilities the heavy burden of parked vehicles from the place where vehicles are supposed to be moving. In Chicago a prohibitive parking regulation covering the entire loop district has been in effect since Jan. 11, 1928, and it has speeded up traffic for various agencies from 25 to 50 per cent. Instead of discouraging the use of the private passenger-automobile, it has increased its use by 18 per cent, which is far beyond the increase in the use of any other agency in that district. Since that regulation has gone into effect, two garage projects totaling a cost of $20,000,000 have been started. That is one solution; such physical appurtenance to streets must be constructed in the larger cities.

A point that is very close to motor-vehicle operators is that, where streets are crowded and trucks and coaches cannot move faster than 3 or 4 m.p.h., no individual operator has a right to stand a dead vehicle, or even a vehicle that is being loaded or unloaded, with its rear end to the curb. This frequently blocks two-thirds of the street; it is the old horse-and-wagon way of doing things. Loading and unloading facilities must go inside the building line. They are going inside the building lines wherever operators of terminals or constructors of commercial establishments have enough vision to see that they can no longer utilize the most valuable public transportation property that exists for one of the cheapest uses to which it can be put. You operators of motor-vehicle fleets can be of assistance in that respect in your individual communities.

Regarding the physical characteristics of the streets, no matter what we may do toward extending the capacity of our streets on the ground, surface transportation by automotive vehicles will not come anywhere near being adequate in any large city of the United States in the future. The crux of the congestion problem in American cities is at the intersections.

Grade Separation Must Come

Assume two well-designed highways, conceive of them being used by vehicles to the utmost density possible and then imagine one highway being laid across the other at grade; neither of those highways will then have more than 50 per cent of its former capacity, for one traffic line must be stopped one-half of the time to allow the other traffic line to move. Under present methods of control with signal or even by police-officer operation, sufficient lost motion occurs in that alternation so that actually we use those streets to only about 34 per cent of their capacity. This situation calls for a development that I should have looked upon as extremely visionary six or seven years ago, but which I think so inevitable now that I can speak about it with entire confidence; it is this: Just as we have now adopted as general and standard practice the separation of the grades of important rail lines and highway routes, so we must face immediately—we are already too late in many cases—the separation of grades of important thoroughfares at strategic points within our cities and the separation of the grades of intersecting main highways. I know of one city on the Atlantic seaboard whose whole traffic problem could be reduced to a very minor one if it put in six grade separations at the crossings of its important arterial highways.

This leads to a subject that is merely an expansion of this idea; that is, that the elevated road, the separated grade route or super-highway, which is a protected right-of-way, will become as inevitable, in metropolitan development especially, as other developments of a similar character. No city in the United States that has attained a population of 1,000,000 could any longer carry with efficiency the mass of its people on surface car-lines; so New York City, Philadelphia, Boston and Chicago have developed rapid transit by subway or by elevated, taking the great mass-movements off the surface of the streets so that they no longer meet the congestion and add to the complexity. If it were not for the subways and elevated railroads, New Yorkers could never get to work; it would take them a week to get downtown.

Super-Highways in Three Cities

The same economic factors that have forced rapid transit for rail agencies in the metropolitan centers will force rapid-transit highways. This is not at all visionary; New York City now has well-developed plans, not financed as yet, for the creation of a rapid-transit highway along the shore of the Hudson River. Boston has an enabling act in the Legislature to empower the city to convert one of its old elevated structures, no longer needed for rapid transit by rail, into a highway over one of its most important thoroughfares. Chicago is conducting studies to show the feasibility of a super-highway system serving the whole network of highways in Cook County. In fact, Chicago already has a highly efficient rapid-transit highway in use. There one can see what rapid transit by automotive vehicles is like. From the heart of the loop district one can drive north for 3½ miles at an average and safe speed of 40 m.p.h.

When we have conditions of that kind, under which we are getting somewhere near the potential ability out of our automotive vehicles, we are enjoying economies and savings that are valuable. The only thing that prevents the wider adoption of the elevated highway at present is merely the establishment of its financial or economic utility. For what purpose was the Holland Tunnel constructed under the Hudson River at a cost of $50,000,000? To save the delays incident to moving automotive vehicles across the Hudson River by ferry-boats. Those tubes are paying for themselves; they are economically sound. Fifty million dollars for what? Not more than four miles of transportation. The best and most expensive type of elevated highway of which one could readily conceive would not cost more than $5,000,000 per mile. The economic justification is there. Our cities should ascertain the facts, provide the finances, and proceed to do these things. We shall get to the point where we can use our passenger and commercial vehicles to somewhere near their efficiency.

Should Have Broad Vision

Sometimes people are still heard to say, "I guess the automobile is here to stay." That is a weak attitude; it is the wrong attitude to take. The motor-vehicle is just beginning its service to American industry and commerce and to the American citizen. We should have broad visions; when we see the City of New York or the State of New Jersey tunneling the Hudson River and building vehicular tubes for a few miles at a cost of $50,000,000, I think it should give us an inspiration to have rather large visions for our own communities.

It may seem like an anticlimax, after talking about a $50,000,000 vehicular tunnel and these other big projects which, notwithstanding their size, are inevitable, to come down to such a meager subject as the traffic officer, who usually is thought of as the symbol of traffic control. Actually, he should no longer be the symbol of the operation of automotive vehicles in any American city, for reasons which I shall give you shortly. Having mentioned briefly a few of the tendencies and implications in the field of physical construction of our street systems, I want to point out the opportunities for improvement of traffic conditions through the better operation of automobiles, particularly those that operate in fleets where there is discipline over them, and the control of traffic by the public agencies.

You who operate fleets hold in your hands an opportunity to relieve a large part of the present irritating congestion upon the streets. You know the load factors in your own cities, whether you operate truck fleets or passenger-vehicle fleets. Your vehicles are frequently traveling over streets to make deliveries or hauls, perhaps loads of less-carload freight between terminals or carrying passengers. These often are filled to only 25, perhaps only 10, per cent of capacity; before a run is half over the vehicle is only half full at best, yet half a dozen other agencies are running similar trucks over the same route and serving the same customers. Coordination of operations both of commodity carriers and by passenger carriers certainly promises one means of relief for traffic congestion, through the elimination of a tremendous number of unnecessary vehicle movements over the streets.

Opportunity of the Operators

Another opportunity lies in the distribution of commercial operations over the streets at off-peak hours. We have, in the public streets of the typical American city, a tremendous plant. What do we do with it? Starting at 7 o'clock in the morning we jam it full for the next 8 or 10 hr., trying to get everything done in one shift. In the evening there are, in most cities, comparatively few pedestrians and vehicles on the streets. What do we do with our streets during that third shift between 11 o'clock at night and 7 o'clock in the morning? Nothing; a half dozen garbage wagons run over them. I submit that this is uneconomical operation. If our traffic flow in any American city were spread evenly over the 24 hr. of the day, or anywhere like evenly, there would be no traffic congestion.

One of the most influential commercial operators in the United States made this statement: "If I could make all of my l.c.l. cartage movements between 9 o'clock at night and 7 o'clock the next morning, I could assume every cartage contract in this city at 66 per cent of what is being paid now and pay my men time and a half for overtime."

The railroads are conservative in such matters. They hate to put electric lights in their terminals so they can work at night. Merchants, even the largest operators of retail establishments, hate to provide a locker-room so that goods can be delivered to it, but that is going to be one of the inevitable tendencies.

Another way in which public truckmen can help is by routing traffic over the less congested routes. In a study of traffic conditions in Boston, which was completed some months ago, we found that on Tremont and Washington Streets, two of the narrowest and most

congested streets in any American city, 15 per cent of the total traffic consisted of trucks that had neither a pick-up nor a delivery to make in the central business district. Yet there were plenty of alternative routes for them to follow to avoid the congestion.

Still another matter which I think is of great importance is that drivers, whether of motorcoaches or trucks, be instructed to follow regulations that are sensible and reasonable and to avoid practices which obviously cause congestion. When a truck backs up to a curb on a narrow street and holds up a street-car with 50 tired workmen aboard and a string of autobiles behind, the driver of that truck is not doing the automotive transportation business of the city any good.

About 25 years ago the railroads were believed to follow a policy of "the public be damned." Unfortunately, a close similarity exists between that famous statement, which the railroads have been trying to live down, and to eliminate which from the public mind they have spent millions of dollars, and the statement so often made that the man with the biggest truck gets the right of way. I submit that for consideration.

Should Support Uniform Traffic Codes

A need exists in this Country at present for uniformity in the movement and regulation of traffic. The Society has contributed generously to uniformity in the automobile industry. Where would the industry be today without the standards the Society has erected for it? Motor-vehicles are no longer operated in cities alone. They are operated across States and across the Nation. As much as 25 per cent of the total traffic in a State may be foreign traffic, particularly in those States in which the summer traffic is very heavy because of tourist travel. This means that it is imperative that we have basic uniformity, regularity and standardization in the movement of traffic.

In this connection I want to mention three important documents, because I hope that the truckmen are going to participate, as many undoubtedly are now participating, in matters of traffic control and relief in their own communities. These documents have been developed under the sponsorship of the Department of Commerce. One is known as the Uniform Motor-Vehicle Code, designed to bring into reasonable conformity the operating laws and regulations of the various States. The second document is known as the Uniform Model Traffic-Ordinance, designed to harmonize with the uniform State code and to give at least basic uniformity in the control in American cities. And the third document, developed by the American Engineering Council, under the same sponsorship, has set forth a uniform code of motor-vehicle signs and signals.

When these codes are widely adopted, as I think they will be with such assistance as your organization and others may give them, it will not be long before we shall have a much more satisfactory traffic condition in most of our cities.

Traffic Control Needs Engineering Study

And now a final point: I said that the traffic officer was a symbol of traffic control. He should be the symbol of reasonable and proper direction of traffic and enforcement of traffic laws. I say "direction" first because I consider it the more important. But he ought not to be the symbol of control in any American city. The setting up of a traffic-signal system on the main streets of any city in the United States cannot be done successfully by a non-technical observer. I shall go as far as to say that even a parking regulation in any city cannot be established by casual lay opinion. One of the reasons we have so much controversy about these various regulations today is that they are haphazard regulations. Nobody believes in them; nobody knows anything about them. They are merely the result of someone's opinion of what will or will not happen. Facts are as readily obtainable, and can be as accurately analyzed, and conclusions of an engineering character can be as accurately drawn in this field as in similar fields of engineering activity and administration in city government.

Whereas six years ago no one ever heard of traffic-control engineering, 12 of the largest cities in the Country have such agencies today. No city should be without a technician possessing engineering training, who is capable of finding the facts and presenting them effectively to his public so that regulations controlling traffic and improvements for the benefit particularly of automotive traffic shall be in accordance with reason and propriety.

The present traffic situation, involving as it does millions and even hundreds of millions of dollars of loss to operators, to their communities, and to the Nation, demands, it seems to me, the earnest consideration of men who are manufacturing and operating motor-vehicles. You who are operating them are doing something more than dealing with vehicles; you are selling transportation to the public. You are laying the foundations for the development of automotive transportation in American cities and throughout the Nation. Is there any group in the United States—I am speaking to this section of the Society of Automotive Engineers—that should have a greater interest in, or that is better qualified because of its experience to take an interest in, this problem than you are? Do not give all of your attention to your vehicles; pay a little attention to your roadbed.

Short-Haul Passenger Transportation

By A. T. Warner[1]

Transportation Meeting Paper

SHORT-HAUL transportation of passengers is defined, for the purpose of the author, as traffic on lines on which the average ride is about three miles, on routes that traverse heavy-traffic streets through an area of dense population, where the operating speed is relatively slow and a large number of stops are made per mile.

Development of the motorcoach is traced briefly down to the modern city-type gasoline-electric coach, of which type the New Jersey corporation with which the author is connected now operates approximately 900. The advantages of this type for city service are dealt with, emphasis being placed on the elimination of gearshifting, which is a boon to the driver, results in important savings in maintenance and affords a safer and more comfortable ride for the passengers.

Seating arrangements are described for motorcoaches in which standee loads are carried, and an invitation is extended to engineers to submit practical suggestions for providing comfortable and usable passenger-seats over the wheel-housings that will enable retention of the standee "well" at the front part of the body.

The six-cylinder engine is said to be needed for its flexibility, greater power and acceleration as compared with the former four-cylinder engine; and it is asserted that power brakes are becoming practicable for all the larger motorcoaches. The gasoline-electric coaches, on which the driver has command of the hand brake, foot air-brake and electric brake, are believed by the author to be the safest vehicles using the highways.

The New Jersey Corporation is utilizing the same supervising, operating and maintenance organization for its motorcoaches as for its street-railway service, and experience is proving that this is right.

Since 1924 the motorcoach service has increased from 15,000,000 coach-miles operated and 76,000,000 passengers carried, to more than 55,000,000 coach-miles and 300,000,000 passengers anticipated for this year. One-half of the total transportation this year will be carried in the corporation's 1800 motorcoaches, and the other half in its 1400 street-cars. The service with both types of conveyance is coordinated and unified. Motorcoaches have been substituted for street-cars in two large cities in the State, and the service formerly furnished by street-cars on one-track lines in five other cities or towns is now given with motorcoaches. The place of the motorcoach in the transportation field is asserted to be broadening rapidly.

FOR discussion of the operation of the motorcoach in short-haul transportation, we must first differentiate between what is short-haul and what is long-haul business. No definite line of demarcation can be drawn, but for the purpose of discussion I assume that short-haul traffic is that on lines on which the average ride is about three miles, where the route traverses heavy-traffic streets through an area of dense population, so that the operating speed is relatively slow and a large number of stops are made per mile. With this definition in mind, I divide this discussion into three main topics: First, the development of the vehicle; second, the development of operating forces and operating methods; and, third, the place of the motorcoach as a transportation unit.

Development of the City-Type Coach

The motorcoach of today is a redesign and refinement of the motor-truck. Buses of 10 years ago were mere truck chassis fitted with a passenger-carrying body. They were high, top-heavy, unable to hold the road in wet weather or on ice, lacked ventilation and lights, and had very uncertain braking mechanism. The first change was an attempt to design a chassis that would afford riding comfort with a variable load, and therefore be suitable for the carrying of passengers. This step reduced the height of the chassis and introduced floating springs. Coincident with the adoption of dual wheels on the rear axle, the development of the six-cylinder engine was started, experiments were made with four-wheel brakes, serious study of proper lighting and ventilation was undertaken, and attention was given to the production of a vehicle which would give the rider both comfort and safety.

About four years ago experiments were started with a gasoline-electric-driven vehicle, of which we now have on our lines approximately 900. The most important factor in favor of this type of motorcoach is the elimination of gearshifting. Short-haul transportation means, with us, an average speed of approximately 10 m.p.h. and that the vehicle will have to stop an average of 10 times per mile. Every operator of a mechanical-drive coach, therefore, in the course of 9 hr. of work, has to make 3600 motions of his gearshift lever for passenger stops alone. This figure does not include traffic stops at street intersections or slow-ups at other points where the speed of the vehicle is retarded without stopping to pick up or to discharge passengers. Of these motions, 2700 are made in the process of acceleration. Thus, one can realize the great temptation the operators have to start in second or third speed, abuse the clutch and everything behind it, jerk their passengers by improper operation, and damage the equipment in general. In 1925 we estimated that approximately 80 per cent of our road failures, excluding tire trouble, were due to trouble back of the engine, principally in the clutch. This was the point of greatest abuse. The gasoline-electric drive, which eliminates all gearshifting, has not only greatly reduced this abuse and resulted in an important saving in maintenance, but is also a great boon to the operator and affords a smoother, more comfortable ride for every passenger. We are not yet convinced that this type of coach is the proper vehicle for long-distance work, in which the number of stops per mile does not have the same importance, but it is proving most satisfactory in our city service.

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Our city-service motorcoaches are operating, for the most part, on 5-cent-fare lines, on which large standee-loads must be carried at the peak of the rush hours. This necessitates a body designed for such a standee load and having the seats arranged to accommodate it. We have finally adopted a seating plan that calls for cross-seats in the rear and long longitudinal seats in the front of the body, thus giving a large "well," not only for standees, but to facilitate rapid interchange of passengers in loading and unloading. This leaves a very unsatisfactory cross-seat over the wheel-housing, and we would welcome any practicable suggestion for providing a comfortable and usable passenger-seat over the space now occupied by the wheel-housing. If we have longitudinal seats in the rear to cover the wheel-housings and cross-seats in the front, we establish the well for standees in the rear, which delays passenger movement and seriously reduces the running time and speed.

Evolution of the engine from four to six cylinders has come by the same steps that have produced six-cylinder private passenger-cars and almost superseded the four-cylinder cars. We needed the six-cylinder engine for its greater flexibility, greater power and better acceleration. Power brakes are now becoming practicable on all the larger motorcoaches; in fact, the gasoline-electric coaches now have the hand brake, the foot air-brake, and the electric brake at the command of the operator and therefore are, I believe, the safest vehicles using the highways today.

Operating Forces and Methods

In October, 1923, we started motorcoach operation seriously in New Jersey. At that time we had an organization trained in the handling of local passenger-transportation by the operation of street-railway cars. We believed that this organization should be the basis of our motorcoach operation, that there should be no duplication of effort, a minimum separation of forces, and that the two types of vehicle could be operated and maintained by the same basic organization. Experience is proving that this is right. We are now operating and maintaining our motorcoach fleet along the same general lines that we followed with our street-railway system.

At many of our operating stations the same forces supervise both street-cars and motorcoaches. Our platform men have been transferred from cars to coaches and vice versa. At some terminals the same dispatchers govern the movements of both kinds of vehicle, and our shop forces inspect, maintain and repair both, in many cases under the same roof. Our motorcoach bodies are designed and completely built by the same engineers, carpenters and mechanics who build our street-car bodies. Our operating schedules are laid out so that, where a street-car and motorcoach line parallel each other or serve a common territory, due weight is given to the service on each. This is all part of our program of coordinating these two types of vehicle to give a complete, unified service.

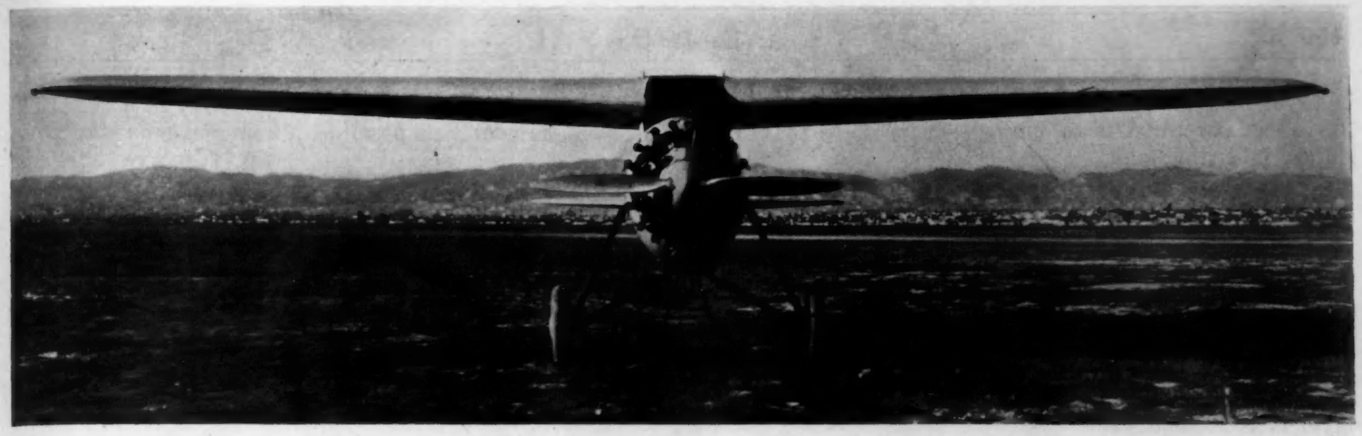
The first important achievement was the development of a safe vehicle designed for mass passenger-carrying. Second to this and of probably equal importance, has been the growth of the field of the motorcoach. In 1924, which was our first full year of motorcoach operation, we operated more than 15,000,000 coach-miles and carried 76,000,000 passengers. This year we shall operate more than 55,000,000 coach-miles and carry more than 300,000,000 passengers. Much of this increase has resulted from the purchase of additional competing lines, but a great deal has resulted from the establishment of motorcoach service in lieu of former rail service. Today the entire local business in the cities of Paterson and Plainfield is handled by motorcoaches. A large part of the service formerly furnished by street-cars in New Brunswick, Camden, Elizabeth, and the Amboys is now being provided by motorcoaches. This was all on routes on which car operation was over single tracks with turnouts. The elimination of turnout waits and the operating flexibility of the motorcoach produced immediate popular approval. This year one-half of our total transportation business will be carried in our 1800 motorcoaches and the other half in our 1400 street-cars.

Curb Loading a Big Factor

The motorcoach possesses elements of safety that the street-car does not have, and, on the other hand, some safety points are inherent in the rail-car. One of the greatest factors that I believe has popularized the motorcoach is the curb pick-up and delivery of passengers. The State law in New Jersey makes it mandatory for all motorcoach stops to be made at the curb. Location of street-car rails in the middle of the street makes it necessary for passengers to cross through the ever-increasing automotive traffic to reach the cars. This danger is eliminated in the motorcoach, and this fact, in my opinion, has produced a greater increase in short-haul traffic for the motorcoach than any other single factor. The motorcoach, being dirigible, can be guided around obstructions, a fact that has both its good and its bad points. The driver of a vehicle following a street-car knows exactly where the car is going; its course is predetermined by the rails, whereas the course of the motorcoach is not fixed. It is an advantage, however, that if there is an obstruction in the street the motorcoach can run around it, whereas the street-car must wait until it is removed.

Motorcoach operation demands an even greater co-operation from city and police officials than street-car operation, because spaces must be provided for stops along the curb, and these spaces must be kept free from encroachment by parked vehicles. Both the motorcoach and the street-car should be given every assistance possible by local authorities to assist in maintaining as high an operating speed as possible. Both are common-carriers and, as such, carrying loads of 60 to 100 passengers, are entitled to more rights on the streets than the private car, the average load in which is one and one-half passengers.

The field of the motorcoach is constantly widening in direct proportion to the development of the vehicle. There is still considerable difference in favor of the street-car for handling mass transportation, as it occurs in the peak hours in our larger cities. The street-car can carry 125 passengers with the same amount of comfort that a motorcoach can carry 60; consequently the economic factor, the cost of service per passenger, remains greatly in favor of the former. Ten years ago the buses seated 12 passengers and were not safe vehicles; today, the modern-type motorcoaches are seating 40 and are safe, commodious, comfortable vehicles. Therefore, the place of the motorcoach in the transportation field is broadening rapidly, and no one can say with certainty what tomorrow will bring.



Fabrication of the Lockheed "Vega" Airplane-Fuselage

By GERARD F. VULTEE[1]

LOS ANGELES AERONAUTIC MEETING PAPER *Illustrated with* PHOTOGRAPHS

THE monocoque type of fuselage construction seems to promise satisfaction of the three requisites of prime importance; namely, high strength-weight ratio, "streamlined" form, and unobstructed interior, according to the author.

The conventional method of building a fuselage consists, first, in the construction of a "form" of the required shape, upon which a layer of veneer is fastened. Other layers are applied, and thus a fuselage shell of two or three plies is completed. But the process is expensive and laborious, involving the handling and individual fitting of many small pieces.

In the process described by the author, a wooden form of the exact shape of one half of the fuselage body, divided on a vertical plane passing through the center line, is built. This form, or pattern, is next suspended in a large box in which reinforcing bars previously have been woven, and concrete is poured in. A reinforced-concrete block weighing from 10 to 30 tons and having a central depression exactly the shape of half of the finished fuselage is thus made.

To assemble a half shell, the outer layer is placed in position in the concrete mold and coated with a casein glue, and the second layer is placed inside the first layer. A coat of glue is given the second layer, the inner layer is put into place inside the other two and air pressure is applied to a rubber bag which fills the space between the plywood shell and the cover of the concrete mold.

After remaining under pressure in the mold for about 8 hr., the half-shell is removed and placed on a drying rack. It is without joints, cracks or laps, perfectly glued throughout and formed to the exact streamline desired. Two half-shells constituting the fuselage are clamped into position on a "skeleton" by special clamps, and automatically align themselves on the framework. They are glued and nailed in place, and cutouts are made for windows and other openings. Installation of seats and fittings completes the structure.

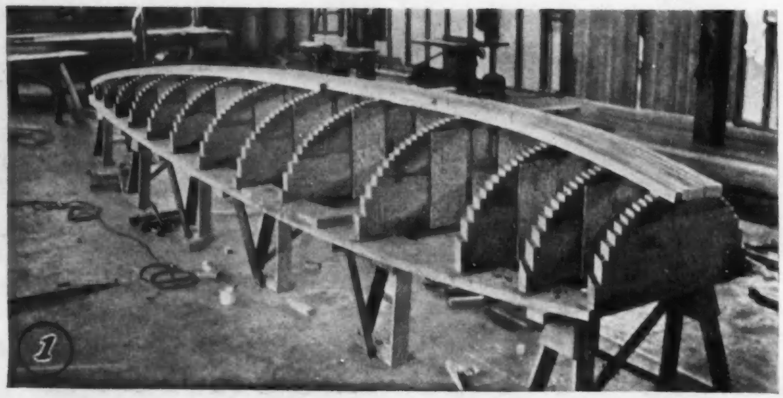
THREE requisites of prime importance govern the design of airplane fuselages; first, the strength-weight ratio must be as high as possible; second, the form must be as nearly as practicable "streamline" in shape, so as to require the least power for propulsion through the air; third, the interior must be unobstructed, because the purpose of the fuselage is primarily that of a cargo carrier. Cost of production and ease of repair are also important considerations, especially from the viewpoint of the commercial operator, who must make his cargo carrier a paying investment, both initial and maintenance costs considered.

The monocoque type of fuselage construction seems to promise satisfaction of these requirements to a greater extent than does any other method. The strength-weight ratio can be made high because of the employment of the stressed material at a greater distance from the neutral axis and also of the elimination of fairing and its supporting structure. The form of the fuselage and its surface texture in our type of monocoque construction satisfies, as nearly as is commercially possible, the requirements for minimum resistance; it is virtually a true streamline shape without surface irregularities. The use of laminated spruce rings or "diaphragms" to support the spruce shell results in an interior which is entirely free from structural cross-bracing members. An additional advantage of this feature is the great reduction of risk in the event of a crash, there being no cross-members to injure the occupants of the cabin. The materials used and the methods by which they are employed in the structure make for a moderate cost in production and ease of repair under service conditions.

The conventional method of building a fuselage consists, first, in constructing a form of the required shape.

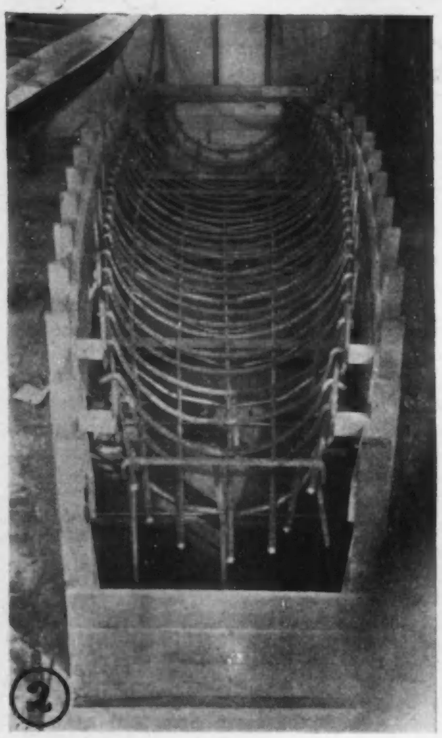
[1] Chief engineer, Lockheed Aircraft Co., Inc., Los Angeles.

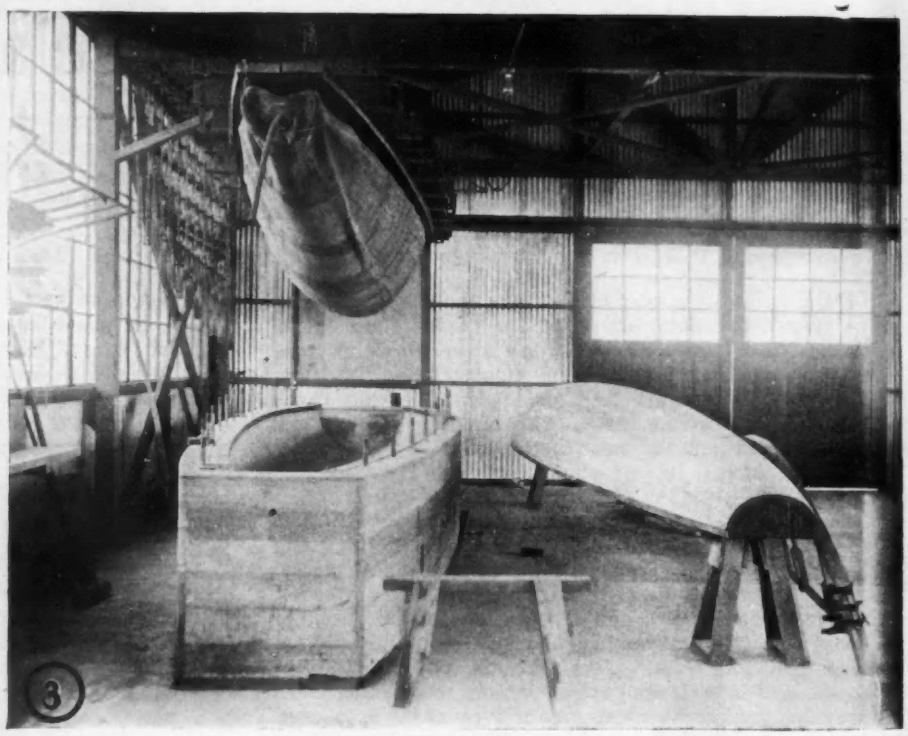
A layer of veneer is fastened over this form. The first layer usually consists of narrow strips 1/16 to 1/8 in. thick, laid diagonally or wrapped around the form. Each strip is separately fitted and fastened to the form by means of tacks, clamps, glue or some binder. After the first layer has been applied, a second layer is assembled, the grain running at an angle to that of the first layer. Each strip is individually glued and is tacked or clamped to the first layer in an effort to produce, as nearly as possible, a homogeneous structure.

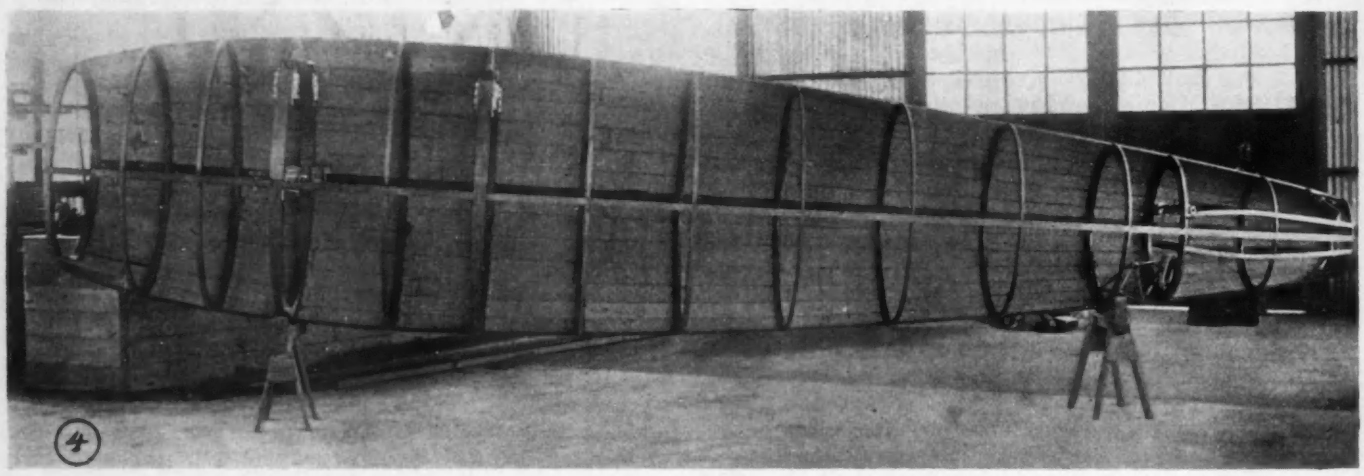


A fuselage shell of two or three plies is completed in this way, the final layer usually being covered with fabric to help in binding the entire structure together and to produce a better finish.

At best, the whole process is a very expensive and laborious one, involving the handling and individ-







FEATURES OF THE LOCKHEED VEGA FUSELAGE CONSTRUCTION

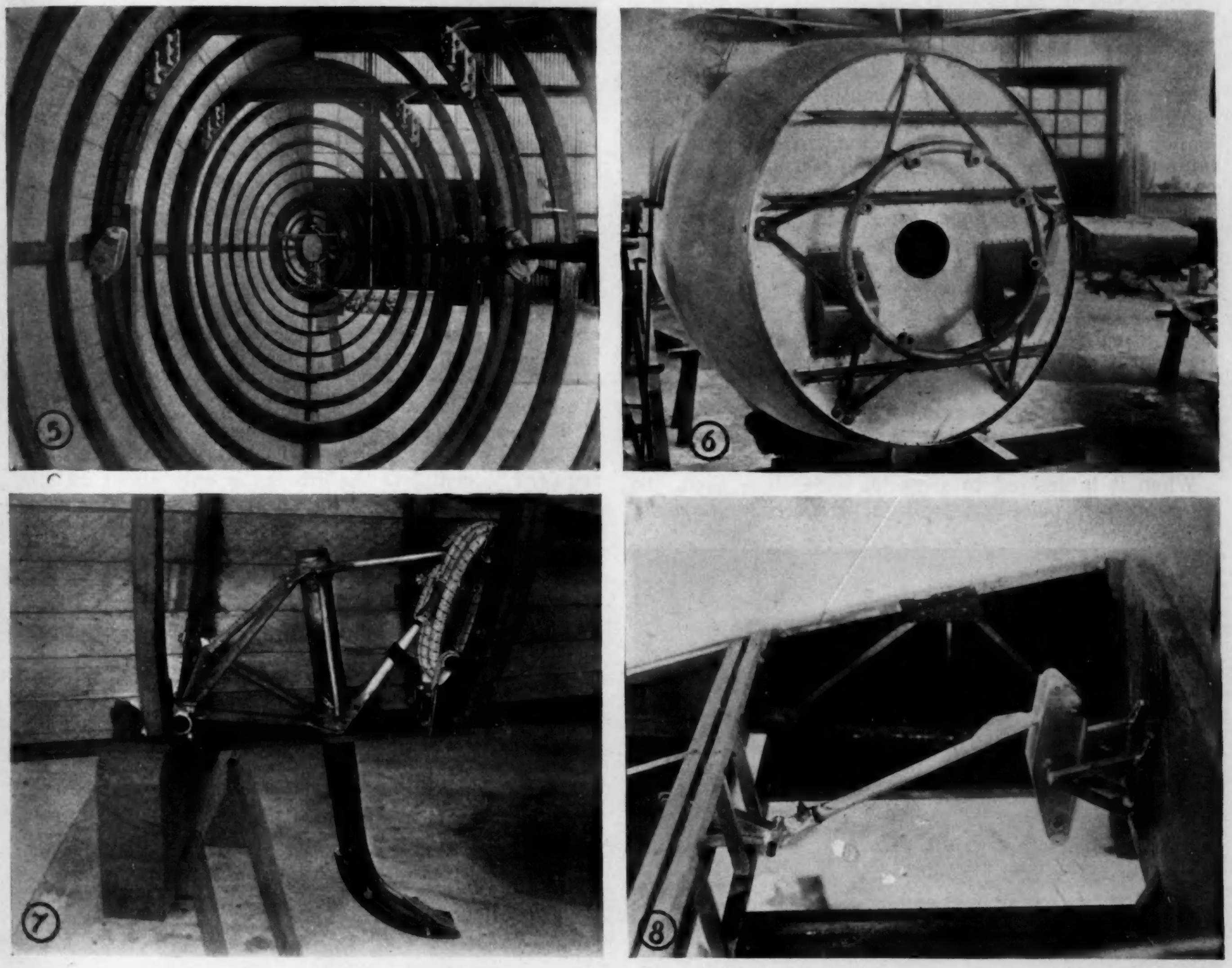
(Fig. 1) Construction of the Form or Male Fuselage-Mold Over Which the Plywood for the Fuselage Shell Is Laid. (Fig. 2) Reinforced-Concrete Box. (Fig. 3) Completed Concrete Form, with Projecting Tie-Bolts for Holding Down the Cover, Which Is Seen Hanging Above, the Rubber Air-Bag Fastened Underneath, and, on the Right, the Male Form with One of the Completed Shell-Layers Resting Over It. (Fig. 4) Finished Half-Shell When Assembled

ual fitting of a great many small pieces. It is impossible to provide a uniform pressure on the glued surfaces, and the result is not all that could be desired to produce the strongest possible structure.

Lockheed Process Described

The process in use at our plant, for which the company controls exclusive patent rights, was developed several years ago by Allan Loughead, Anthony Stadlman and associates. The method of construction used produces a perfectly shaped half-shell molded from three layers of cross-grained spruce which are glued together at one time under heavy pressure to form a perfectly homogeneous unit.

The first step in the fabrication process is the design and construction of a suitable mold. The body lines are first laid out to give the required cargo space, with an elliptical center cross-section that tapers gradually to a circular section in front and a small ellipse in the rear. A wooden form, shown in Fig. 1, is then constructed to the exact shape required for one-half of the fuselage body, divided on a vertical plane passing through the center line. This form, or pattern, is finished very smoothly on the outside, and is rigid and well braced. It is then suspended with its formed or curved surface downward in a large box in which reinforcing bars have previously been woven, as shown in Fig. 2. The box is then filled with a good grade of concrete, which is carefully tamped to produce a smooth cast surface against the wooden pattern.



Details of Laminated-Spruce Rings and Other Fittings

(Fig. 5) Interior of the Skeleton Framework, Showing Longitudinal Spacing-Strips and Method of Attaching Fittings to the Rings or "Diaphragms." (Fig. 6) Engine-Mount Ring of Welded Steel-Tubing Construction. (Fig. 7) Tail-Skid Installation and Method of Attaching Members to the Fuselage. (Fig. 8) Aileron-Actuating Mechanism, Which Hinges About the Top Portion of the Aileron and Is Entirely Inside the Wing

After the concrete has thoroughly hardened, the sheathing is removed from the box, and the wooden fuselage pattern is lifted out. Thus a reinforced-concrete block is produced that weighs from 10 to 30 tons, depending upon the size of the fuselage, and has a central depression which is just the shape of one-half of the finished fuselage. Special alloy-steel hold-down bolts are cast into the concrete at intervals of about 2 ft. along the edge of the form. A wooden cover is fitted flush with the top of the concrete mold and is held in place with heavy steel I-beams through which

the hold-down bolts pass. A large rubber air-bag having the exact shape of the inside of the mold is fastened by cords to the bottom of the cover, as shown above the mold in Fig. 3.

The fuselage half-shell shown in Fig. 4 is made of three layers of sliced, cross-grained spruce veneer, totaling when complete between 5/32 and 3/16 in. in thickness. The inner and outer layers are each about 1/24 in. thick and run longitudinally from nose to tail, while the central ply is 1/16-in. spruce with the grain at right angles to the other two layers. The longitudinals are gore-shaped strips tapering from approximately 1 in. wide at the ends to 6 in. at the center. They are stacked in bundles, clamped between forms, and cut to the required shape about 30 at a time. Each piece is 25 ft. long and, as sliced spruce in this length is not available, a special splicing machine has been built which produces a perfect scarf-splice about 3/4 in. long in the 1/24-in. veneer.

After cutting to shape, the longitudinal gores are temporarily fastened in position on the original wooden body-form by means of a few tacks, and are secured in the proper relation to one another by strips of paper tape fastened along the joints. The inner and outer longitudinal plies are all made up in the same way and, after preparation, can be folded and stored until ready for use. The transfer ring, which is a 2 x 3-in. band of laminated spruce carried around the edge of the wooden form, is arranged so that it can be removed as a whole when necessary.

When it is desired to assemble a fuselage shell, the outer layer is placed in position in the concrete mold,

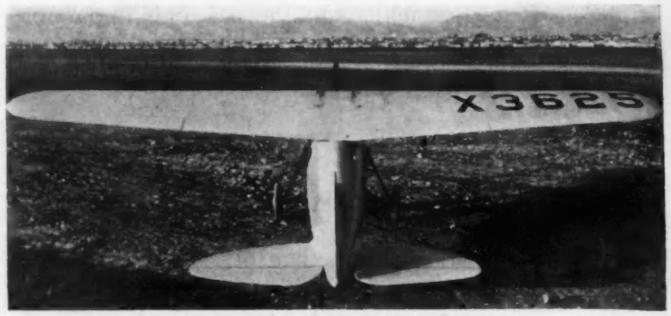


FIG. 10—TAIL VIEW OF VEGA AIRPLANE
The Type of Streamline Section Produced by the Method of Plywood Fuselage-Construction Described Is Evident. Wind-Tunnel Data Show That This Shape Has Considerably Less Than Half the Air Resistance of the Ordinary Steel-Tubing Fuselage

where it is held in place by strips of gummed tape along the edge of the mold. It is then given a coat of casein glue, and at the same time the second or transverse layer, in place on the wooden form shown in Fig. 1, is coated. The second layer is then picked up as a unit by means of the transfer ring, and is inverted in the concrete mold inside the first layer. The second layer is in turn coated with glue on the inside. The last or inner layer is placed inside the other two in the concrete mold, the cover is lowered and bolted down, and air pressure is applied to the rubber bag which fills the space between the plywood shell and the cover. The actual time required to complete the process is only about 20 min. from the application of the first glue until the whole shell is under a pressure of 15 to 20 lb. per sq. in., the total pressure exerted being about 150 tons over the whole sheet of plywood.

Any slight irregularities in the concrete mold or in the thickness of the plywood are compensated by the resilience of the rubber bag, so that every inch of the plywood surface receives approximately the same pressure. The shell remains under pressure in the mold for about 8 hr., after which it is removed and placed on a drying rack where the excess moisture is removed. The resultant half-shell is a homogeneous piece of plywood without joints, cracks or laps, perfectly glued throughout and formed to the exact streamline shape desired.

The "skeleton" framework to which the shell is applied, shown in Fig. 5, consists of a series of elliptical laminated-spruce rings varying in cross-section from 3 in. square, where heavy loads are applied, to about ¾ in. square near the tail of the fuselage, where the loads are light. The rings are held in position by four light spruce strips or "longerons" which serve as spacers and, at the top and bottom, as seam strips on which the two half-shells are joined. Fig. 5 also shows the method of attaching fittings to the diaphragms or rings.

The monocoque shells are clamped in position on the skeleton by means of special strap-type clamps, and automatically align themselves on the framework. They are glued and nailed in place with barbed cement-coated brass nails, care being taken that at points of large load ample gluing and nailing area is provided. Cutouts are made for windows, doors, cockpit openings, and the like, and reinforcing members are used around the larger openings to compensate for the reduction of strength due to the removal of material at the cutout

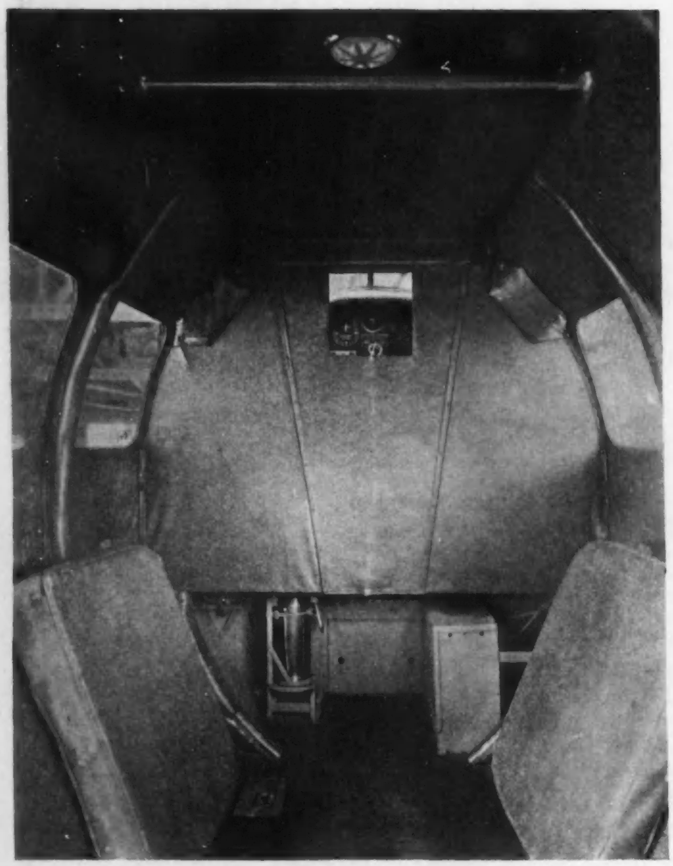


FIG. 9—CABIN INTERIOR, FREE FROM STRUCTURAL CROSS-BRACING MEMBERS

point. Paint or lacquer applied outside, and the installation of seats, controls, a baggage compartment, and upholstering inside, complete the structure.

Other Special Construction Features

Fig. 6 shows the method of mounting the Whirlwind engine. We prefer the welded steel-tubing structure rather than to build out the fuselage with wood construction. In Fig. 7, the mounting of the tail-skid illustrates the fact that all members are mounted directly on the rings or diaphragms, to distribute the stresses over as wide an area as possible. No members are fastened directly to the shell. A feature of the entire construction is that we have tried to keep all controls inside as much as possible. Fig. 8 shows the aileron-actuating mechanism, which hinges about the top portion of the aileron and is entirely inside the wing.

Fig. 9 illustrates the benefit derived by keeping the cabin free of structural cross-members. A serious crash can occur without danger that any of the passengers will be thrown against any sharp structural member that would be likely to cause personal injury or that might fold up on them.

As an example of the advantages peculiar to the plywood type of fuselage construction without structural cross-members, we have had two serious crashes of two different airplanes. Both crashes were of a nature that probably would fold up a steel-tubing fuselage rather completely, and the transverse bracing-members might have injured the occupants very seriously. In one case we had three passengers in the cabin, and in the other, four passengers. In neither of the crashes were any of the passengers injured. We believe this is because of the type of construction. The fuselage has a double curve throughout, which tends to cause it to break outward instead of splintering inward. Further, the fact that the spruce diaphragms are laminated, thus having much the same resilience as plywood, and that the grain is more or less crossed in the laminations, causing them to resist any tendency to splinter, is another feature that minimizes the dangers in a crash.

Regarding the procedure for the repair of the Vega fuselage, we always keep several complete half-shells of the fuselage in stock. In the event of a crash or minor accident which makes a hole, say 1 ft. in size, in the fuselage, we can take out a plywood section between diaphragms and replace it. Whatever the diaphragm spacing is, we merely remove a section of the shell and splice in a section from one of our spare half-shells at exactly the same location. The splice is made carefully and has exactly the same curve as the section that was damaged. When repaired in this way the fuselage is as good as it was originally, and the repair cannot be noticed.

Fig. 10 shows the type of streamline section that we get by using this method of construction. The fuselage has an almost perfect streamline shape, and we know from wind-tunnel data that this shape has considerably less than half the air resistance of the ordinary steel-tubing fuselage. The headpiece herewith illustrates the cleanness of the Vega design and the fact that no struts are used. The concluding illustration shows the finished appearance of the entire airplane, which we term the air-express model, and emphasizes the shape of the fuselage. The model is intended for use as an air-mail plane and has the parasol wing-arrangement.

Cooperation in Transport

By Major E. G. E. Beaumont[1]

Semi-Annual Meeting Paper

Among the manifold activities of the present age, the transport of men and materials of all kinds occupies, as it ever has, a predominant position affecting very intimately the lives of all. Moreover, the author points out that it is recognized that so far as we are informed by surviving historical records, there has been no previous era involving present methods, the multiplicity of apparatus and the complexity of system with which we are now concerned, whether considering land, water, or air transport. It is therefore not surprising that the subject represents the major current of activity of technical associations, conferences, and congresses in different parts of the world.

It is not strange that, as a result of the rapid development occurring in our own time, there has been much attendant inconvenience, disturbance of the industries immediately concerned, and considerable commercial risk. To the student of transport, and even to the superficial observer, there is evidently abundant justification for sustained efforts, by all concerned, to promote efficiency and economy and to secure, so far as possible, the stable conditions without which National prosperity and convenience cannot be maintained.

Suppression of old by new methods and their intrusion into well-established transport-systems brings into prominent view many interesting problems affecting the principal parties concerned; namely, those engaged in the production of transport apparatus and those who operate and maintain it. The paper analyzes the interaction of these principal parties and the directions in which cooperation merits encouragement in connection with land transport.

Published figures of vehicle registration issued in America by the National Automobile Chamber of Commerce and in Great Britain by the Ministry of Transport are given in Table 1, from which inferences can be drawn. It will be seen that the proportions vary considerably and that, whereas in America motor-car production represents by far the greatest activity of manufacturers, in Great Britain the incentive to production is probably about equal for the light and the heavy classes of vehicle when relative values are taken into account. Incidentally, it is interesting to note the very large British motorcycle and cycle-car class, totaling more than 600,000 registered vehicles.

TABLE 1—TOTAL MOTOR-VEHICLES REGISTERED

	United States		Great Britain	
Type	Number	Per Cent	Number	Per Cent
Motor-Cars	19,620,000	87.5	686,232	66
Motor-Trucks	2,730,000	12.2	257,178	25
Motorcoaches	80,000	0.3	100,853	9
Total	22,330,000	100	1,044,263	100

Production of motor-cars to suit requirements admits of comparatively simple solutions, because the characteristics, performance and values are more generally understood and appreciated by the purchasing public. It probably is not inaccurate to say that the demand is more than adequtely satisfied and that the problems calling first for solution are those primarily affecting the manufacturers and distributers. In the presidential address given by me last year before the Institution of Automobile Engineers, I suggested the necessity of securing as great a measure of cooperation and agreement as could be reached among the representative manufacturers' associations of the world, despite the manifest difficulties, to stabilize and retain the commercial balance of the motor-car section of the industry. Since then the trend of development, in America and in Europe, continues unduly in favor of the user at the expense of the manufacturer. Under the increasing stress of competitive selling, the level of prices is still falling and, ultimately, this undoubtedly will react unfavorably upon distributers and purchasers.

In the heavy-vehicle field, covering the great variety of types used for passenger and goods transport, development has been much encouraged and accelerated in the 10 years since the World War. To a great extent this is the inevitable outcome of the very extensive and costly work of road building and reconstruction in America and Great Britain and also in other countries on a somewhat smaller scale. The provision of roads more capable of resisting the wear and tear of heavy traffic has rendered possible the rapid growth of passenger and freight-carrying services, and has led gradually to a situation demanding the attention of all road-transport authorities. In England no less than in America, railroad companies are experiencing the effects of road-transport competition and are under the necessity of determining the true relative fields of rail and road systems.

World Motor-Transport Congress

In connection with these questions, the published report of the proceedings of the World Motor-Transport Congress, held in London in November, 1927, is valuable and enlightening, because it records the state of development and the leading views held by authorities in the principal countries of the world. Two papers contributed by delegates of the Society—one by N. D. Ballantine, on the Necessity of Coordination of Rail and Road Transport, and the other by David L. Bacon, on Benefits of a Coordinated Rail and Highway System in New England—are particularly referred to as setting forth, on the one hand, the problems to be faced and, on the other hand, their successful experience already obtained as a result of a systematic endeavor to solve those problems.

In the course of his paper Mr. Ballantine dwelt upon the fact that, while it is common to talk about cooperation, it is nevertheless frequently a fact that the essence

[1] President of the Institution of Automobile Engineers, London, England.

of the matters involved is not realized; subsequently, in his conclusions, he states that the lack of convincing information regarding costs and savings represents the main difficulty. He also says that coordination should be easier of accomplishment in England, where there exists an Institute of Transport, and that, doubtless, progress has been made. As a member of that Institute I agree substantially with his statement; but, on the other hand, we cannot yet point to an example of substantial progress in the striking form referred to by Mr. Bacon in his interesting description of the coordinated development of rail and road-transport activity of the New York, New Haven & Hartford Railroad. We can, however, point to the vision displayed by at least one leading British railway company, namely, the Great Western Railway Co., which has employed road motor-vehicles for about 25 years as feeders to its system and has continued to do so to an increasing extent for both passenger and goods transport.

At present, in England, the rail and road controversy is at its height and the subject, having engaged the attention of Parliament in connection with foreshadowed new legislation, can be expected to result in thorough investigation before a Royal Commission.

As a visitor to the United States, I should be glad to learn how you are dealing with transportation problems, and whether you parallel the work of our Institute of Transport by means of a similar association or by means of a permanent transportation section of the Society of Automotive Engineers. There can be no doubt that the thorough discussion of the results of employment of the different transportation agencies, either independently or collectively, by those concerned in railroad, street-car, subway, highway and water transport, serves a most valuable mutual educational purpose.

Understanding of Cost Fundamentals

It is desirable to emphasize the necessity of a clear understanding of the fundamental principles of cost of operation and maintenance, not only by operators but equally by vehicle manufacturers, so that mutual appreciation of the problems can be assured. It is a subject that has engaged my close attention for a number of years, and I refer to my paper on the subject; namely, the Maintenance of Commercial-Vehicle Fleets[2]. Probably, in America no less than in other countries, considerable harm results from ill-advised and uneconomical employment of types of vehicles for purposes for which they are not really suited. Such operation by numerous small independent owners frequently is economically unsound and often ends in failure, but not before there have been injurious effects upon the more substantial concerns having satisfactory organizations and resources.

To focus discussion, Table 2 is given to indicate the apportionment of expenditure and to enable the question to be asked whether, in the offer for sale and the purchase of vehicles, sufficient consideration is given to the influence of cost items in deciding upon the most economical fleet-units. This table represents the average case of commercial vehicles carrying about a 3-ton net-load a distance of 250 miles per week. For comparison, the effect upon distribution of cost items of operating at the higher rate of 400 miles per week is shown in

[2] See Proceedings of the Institution of Automobile Engineers, vol. 19, p. 171.

TABLE 2—OPERATING-COST ITEMS

Item	250 Miles per Week Per Cent	400 Miles per Week Per Cent
Fixed Charges		
Interest on Capital	$4.25	$3.60
Depreciation	12.75	11.80
Insurance	1.25	1.00
Management	3.50	2.75
Taxation	3.50	2.75
Garage	3.75	2.90
Wages of Driver and Helper	35.00	28.50
Total	$64.00	$53.30
Variable Charges		
Fuel	$16.50	$21.70
Lubricants	1.50	2.00
Repairs and Renewals	18.00	23.00
Total	$36.00	$46.70
Grand Total, per cent	100.00	100.00
Total Expenditure per Week	$75.00	$92.00

the second column. It will be seen that four principal items claim attention; namely, depreciation, wages, fuel and repairs. Further, as a readily remembered approximate division when working on the basis of 250 miles per week, fixed charges, wages and running costs are each about one-third of the total.

At the higher rate of working, 400 miles per week, the division necessarily changes and becomes roughly: fixed charges one-fourth, wages one-fourth, and running charges one-half, respectively. At the foot of each column the total expenditure per week is given as $75 in the one case and $92 in the other, and the value of the component items can be referred to if required. Table 2 brings out some of the main points for consideration. For example, vehicle cost per passenger seat or per net ton of carrying capacity diminishes with increase of total capacity, and the same can be said of the other three principal items.

Here, then, is good reason for the operator to use the high-capacity vehicle so long as he can keep it well employed, and for the manufacturers' technical sales organization to be sure its prospective customers fully realize this. By the establishment of confidence based upon sound knowledge, business relations will be strengthened to the advantage of both parties. The theme might be developed at some length, for it is well sometimes to remember that in most transport transactions of some size there are not less than three parties to whom cooperation is of importance. I refer to the manufacturer and distributor of vehicles, to the transport operator or manager, and to the repair and maintenance organization. Reconciliation of the views of these three sometimes constitutes a very delicate problem.

Referring to Table 2 again, we can assume that the first two parties agree that the work in view can be done at the higher rate with vehicles of an agreed type and with the reduction of cost shown; namely, about 30 per cent as compared with the lower rate of working. But has the third party been consulted and is it realized that the maintenance and running charges and the different provisions entailed thereby begin to predominate, although the increased total expenditure is completely justified? And there may equally be lack of appreciation in the opposite direction; namely, the failure of the transport operator to utilize the vehicles at reasonable working rates, coupled with a demand for more equip-

ment despite the promptings of the other parties who realize the essential requirements.

It may be urged that these are simple, even elementary matters, requiring little discussion; and yet, on reflection, it will be found that neglect of these simple points still accounts for the greater part of the unrealized economies in transport. The unnecessary double journey of the unsuitable small vehicle and, conversely, the partly loaded large vehicle, are to be observed too often. Finally, the overloading, overspeeding, run-to-a-standstill class of user continues to be in evidence, to the sorrow and discomfiture of most manufacturers.

Cooperation between Technical Staffs

A form of cooperation of great value and growing to be recognized as of first-class importance is the maintenance of close contact between the technical staffs of the manufacturers and the transport firms. By this means only can really sound development be assured, for it is undoubtedly true that provision in the design and testing stages preceding actual production does not usually include sufficiently the valuable operating mass-experience of the users. Some well-established firms with organized service departments recognize this, and probably in such cases chief engineers and designers of chassis and body equipment follow their natural inclination to observe and note the peculiarities of use and misuse of their products, not only in ordinary and extraordinary service, but also in the repair shops. Expeditious, convenient and economical repair of vehicles has of course commanded attention, but much remains to be done. It not infrequently occurs that design which is determined mainly from the standpoint of minimum production-cost does not minister to the needs of the user, who naturally seeks the maximum economy in maintenance and the minimum lost working-time while repairs are in progress.

For modern transport requirements, facility of removal and replacement of chassis units is essential, and it is also much to be desired that in the renewal of worn parts it should be unnecessary to reject main components. The time has in fact come for the old policy of general overhaul to be revised and largely relinquished in favor of continuous maintenance by the replacement of wearing or accidently damaged parts. To exemplify this, reference may be made to the present position with regard to engine-cylinder and piston construction. Higher duties with accompanying higher speeds, temperatures and pressures, and the increased activity of vehicles in mileage rates has brought about the necessity of more frequent engine repair, though not necessarily more frequent per 1000 miles worked. The reboring and regrinding of cylinders, the provision of special oversize parts, and the recutting of valve seats, will give way to renewable cylinder-liners, standard pistons, and either removable valve-seats or the valve-in-head construction involving only discarding of the less expensive component.

Trends of Development

In the course of the 1928 engineering conference of the Institution of Civil Engineers in London, the subjects for debate included the development of the small high-speed internal-combustion engine covering the types employed for all automotive purposes. The question of rate of wear resulting from the much increased horsepower output per unit of cylinder volume received attention, and the opinion seems to be forming that modern design requires the making of special provision for the increased wearing-rate if the benefits of the more efficient light engine are to be realized and retained.

In connection with general legislation, taxation, and local State or city ordinances and regulations, the nature of the control or restrictions in different countries varies to a great extent and has considerable influence upon constructional development. Regulations may be unnecessarily obstructive in effect, just as their insufficiency or unsuitability may discourage true advance. Hence, cooperation in these matters and unrestricted discussion of essential details in the regulations to be imposed assumes great importance. The record of legislative control in Great Britain forms an interesting study in itself, and presumably our experience has been repeated to a great extent in America.

Usually, motor-vehicle-transport development has outstripped the current legislation and has led almost continually to a proportion of recognized and largely tolerated law-breaking, pending the issue of tardily devised new regulations. In England this has applied to all-embracing questions such as laden and unladen weights, axle-weight limitations, wheel and tire construction and dimensions, over-all dimensions and turning radii, and has permitted maximum speeds of travel. Approaching new legislation promises to achieve in the Road Traffic Act the consolidation of all our old Acts and Statutory Orders, and thereby the removal of much uncertainty and not a little confusion in interpretation. It is also becoming recognized that in our Ministry of Transport there is definitely helpful control directed by careful study and knowledge of the actual requirements.

THE DISCUSSION

PRESIDENT W. G. WALL[3]:—Will Major Beaumont describe the types of vehicle, such as the double-deck vehicles in London, and also comment on the use of the sleeve-valve engine?

MAJOR E. G. E. BEAUMONT:—In London there has been a steady growth in the size of vehicle. At one time the 44-seat double-deck bus was the rule. That was replaced by the 54-seat and then by the 56-seat buses; recently, the seating capacity has gone up to more than 60. Those are double-deck vehicles with covered tops so that passengers can be carried comfortably in bad weather. They are of the six-wheel type, on pneumatic tires, and represent the latest development that is just now beginning to be visible in London. The majority of the buses in London are still of the solid-tire type, but there is a move to change over to pneumatic tires. That is taking place first on the suburban services, not on the busy main-street routes in the metropolitan area.

The high-capacity bus is also coming into use on a considerable scale in the other principal cities. I be-

[3] M.S.A.E.—Consulting engineer, Indianapolis, Ind.

lieve that in Malton, in the Midlands, they have capacities of 80 seats per vehicle on the trolley-buses that operate from an overhead electric wire.

As to the general characteristics of the vehicles, the engine power is from 45 to 50 hp.; the transmission is by four-speed transmissions to worm-gear rear axles; and the bodies are all of the rear-entrance type, the driver always being separated from the passengers, and the stairway for admission to the upper deck always leading from the rear platform. The tendency is to lower the level of these buses so that passengers have to make only one step from the roadway into the bus. That tendency has become more marked because of the necessity of preserving a reasonably low center of gravity and of keeping down the over-all height of the vehicle, so that it can pass under bridges and difficult places in the road.

Nearly all the engines are of the poppet-valve type. The sleeve-valve engine does not seem to make great headway. I think one might safely say that the number of sleeve-valve engines employed is not more than 5 per cent of the total number.

About 800 gasoline-electric buses are in operation in London, and they have been in use continuously for about 18 years. For dense-traffic work, there seems to be a proper place for vehicles of that type. They have some advantage in freedom from the wear and tear resulting from the continuous operation of the clutch, transmission and brakes. Control of the gasoline-electric bus is rather easier for the driver, but this type is in the minority; I suppose 4000 or more mechanically controlled buses are in operation in London.

We still have a large number of steam-driven vehicles. They held their place originally because they were heavy-type passenger-machines and because the larger the machine that can be employed and kept at work, the more economical is the transport per net ton-mile. Now that the large gasoline-electric vehicle is available, the tendency is to cease to use the steam vehicle, and I think this tendency will continue.

M. C. HORINE[4]:—The gasoline-electric vehicle is undergoing considerable development in this Country; it has a new lease of life due to certain important electrical developments and improvements. It is a very different vehicle from the 14-year-old make that is operating in London, and it bids fair to become very popular in our larger centers where frequent-stop service makes valuable the better acceleration and easier control, and the superior braking ability on downgrades.

MAJOR BEAUMONT:—I understand that you find it is only in the dense-traffic areas that the gasoline-electric vehicle is really justified.

MR. HORINE:—We think as a rule that seven stops per mile is the minimum to make the gasoline-electric vehicle pay, except in cases where the street-grade problem is serious, with many stops to be made going up and down grades. In such localities electric braking and the ability to accelerate from a stop on a steep grade gives the gasoline-electric vehicle great advantage.

[4] M.S.A.E.—Manager, sales promotion department, International Motor Co., New York City.

Exports and Automotive Prosperity

BECAUSE of the spectacular speed with which the domestic market for automobiles has grown, the foreign sales of our automotive units have not received the general attention they deserve.

In 1927, foreign buying of our automotive products ranked third in our classification of exports. It was surpassed only by exports of raw cotton and petroleum products. Its valuation of $406,000,000 surpassed our exports of wheat and flour by $82,000,000. It was double our exports of iron and steel and 60 per cent greater than our exports of industrial machinery. Foreign purchases of new motor-vehicles by countries outside the United States in 1927 equalled new motor-vehicle registrations in 20 of our States put together. The best part of the picture is that, in spite of its present size, our motor-vehicle export trade is making only a beginning and its growth offers the most favorable solution for the full employment of the automotive production capacity. Too much stress cannot be put upon this phase of automotive exports.

The growing influence of the automobile as a necessary part of the economic life of civilized countries places it outside of the category of luxuries and puts it into that of a necessity for social and economic progress. To that extent the growing use of automobile equipment by the world as a whole depends only in part on wealth. To an equally great extent it is an essential factor of that industrial efficiency to which every major country of the world is aspiring.

On the practical side there are not a few handicaps to this filling of an immense potential demand through the sale of American cars. These handicaps, to mention the main ones, are tariff barriers, gasoline prices and taxes abroad, poor roads, competition of native manufacturers, and the poverty of potential purchasers.

Even under unfavorable conditions, the exports of American automobiles are growing. Five years ago we were exporting 78,000 cars and trucks. Last year we exported just short of 400,000. This year, from the figures of the first five months, we should probably export about 450,000. Counting in foreign assemblies and Canadian production, our exports last year amounted to 640,507 units as against 375,000 five years ago. This year we shall probably run close to the 800,000 mark in exports of all kinds, including Canadian production.

EXPORTS ESSENTIAL TO MAINTAIN PRODUCTION

At our present capacity the automotive industry needs an output of close to 4,000,000 units a year for reasonable prosperity. This year the replacement demand will probably be about 2,250,000 cars in the United States alone. Canadian production will run probably around 225,000, or the two together close to 2,500,000. New buyers in 1927 were approximately 1,000,000, the lowest since the depression of 1921. If we assume that as the low point of new buying, it becomes necessary for domestic exports, apart from foreign assemblies and Canadian production, to equal 500,000 units a year to bring us up to the 4,000,000 level. This year new buying is running ahead of last year and will easily bring about the 4,000,000. The safety valve, however, lies in an increase in our foreign sales which would bring them close to 1,000,000 cars so that, in a year of relative depression of domestic buying, the automotive industry could still depend upon what looks like its minimum of reasonable prosperity. With European conditions making marked progress toward financial stabilization and industrial recovery, present prospects are for continued large expansion of exports of American automobiles.—J. R. Nutt, president Union Trust Co., in *Trade Winds*.

European Roads and American Cars

Discussion of the Tore Franzen Semi-Annual Meeting Paper[1]

FINDINGS resulting from a first-hand study of car-suspension problems as presented by Continental European road conditions, with particular reference to such complaints as "weak springs" and "striking through," as they relate to American cars, reveal two general types of European road and two types of motorist.

The sportsman who drives his own car at high speed over the old stone roads, now rough and poorly maintained, cares little for a smooth ride but complains of "striking through" of the frame on the axle. The larger class of owners, who want to ride in comfort and whose cars are driven by chauffeurs, frequently use very low tire-pressure and consequently shimmying often results.

Owing to a strong demand for quietness in the better cars, over-oiling of the springs and shock-absorbers is rather general and striking through occurs. Stiffer springs are the obvious preventive in this case. For the other type of service demanded, it should be fairly simple to develop a special suspension that need deviate little from present American spring practice, but particular attention should be paid to making shock-absorbers fool-proof, quiet and effective.

In the discussion it is said that in the great network of roads in this Country we probably shall always have some road conditions like those in Contiental Europe, and that the problem is to devise a suspension that will afford a soft, easy ride on smooth roads and also "take the bumps" without severe jolting. It is suggested that some experimental work might determine the best driving speed for comfortable riding under various conditions of road surface.

Independent wheel-springing and the use of helical springs or rubber or gas are suggested as possible solutions of the problem. The prevalent wagon-type of suspension is criticized as out of place on the automobile and a complete revision of the spring suspension is urged.

The author of the paper, however, defends the semi-elliptic spring as being simple and inexpensive and made of material that is greatly superior to that available to wagon builders of pre-automobile days. He believes the riding-qualities of one European car having independently sprung wheels would be unacceptable to the American public, and that another European car with such a suspension would be very expensive to build.

CHAIRMAN B. B. BACHMAN[2]:—The application of the American automobile to European road conditions unquestionably is a relatively important factor in our present manufacturing and sales programs. I was particularly impressed with the changing relationship between the character of roads in Continental Europe and in America to which Mr. Franzen referred. In 1911, when a delegation from the Society made its first pilgrimage to Europe, one of the topics of conversation between the members of the party and the European engineers whom they met was the contrast in the road conditions the American engineer had to face in the development of automobiles and those which existed in Great Britain and Continental Europe. In the years that have intervened we have seen the steady development of a road system that in its entirety probably is second to none.

On my trip from Philadelphia to Quebec for the Summer Meeting this year, it was interesting to compare conditions, particularly through New York State and the Adirondacks, with those on a trip I made through virtually the same territory about 1914 or 1915. At that time, New York State enjoyed the reputation of having the finest roads in the Country. So it was somewhat disconcerting this year to see that roads which were considered excellent in those days had greatly deteriorated and were in a state calling for complete rehabilitation.

W. R. STRICKLAND[3]:—The problem brought out in the paper may seem a long way off, but all through the United States we have the same conditions where good roads have gone to pieces and have not yet been rebuilt. Our network of roads is so vast that we probably are bound to have that condition continuing forever, because it does cost money to rebuild them. Even the concrete roads develop chuck-holes and breaks. So I think we shall have to effect a compromise in the riding-qualities of a car between the soft, easy riding and "taking the bumps," going as far as we can in both directions in the design of the springs, the suspension and the shock-absorber equipment.

We are progressing rapidly and have arrived in a great many cases, but, no matter how good we make the suspension and the control, we shall always be behind the demand, because the American driver will drive as fast as the condition of the road will let him. He will govern his speed by his feelings in taking the bumps, so the chassis must, to a large extent, be designed to pass over the severe bumps without excessive jolting of the body.

RELATION OF SPEED TO ROAD CONDITION

CHAIRMAN BACHMAN:—A canvass of the opinions of the members who drove from Montreal to Quebec as to the character of the road between the two cities might be enlightening on this subject. I have talked with a number whose opinions of the road vary from "good" to "rotten." I think the opinions are purely a reflex of the speed the different individuals wish to make.

[1] Published in THE JOURNAL for July, 1928, p. 81. The author is assistant chief engineer of the Detroit Steel Products Co., Grosse Pointe, Mich.; he was formerly connected with the American Express Co.'s office in Paris, France, and is a member of the Society. An abstract of the paper is reprinted herewith, supplemented with a synopsis of the trend of the oral discussion.

[2] M.S.A.E.—Engineer, Autocar Co., Ardmore, Pa.

[3] M.S.A.E.—Assistant chief engineer, Cadillac Motor Car Co., Detroit.

My own experience was that satisfactory riding for all of the occupants in the car I was driving could be obtained at speeds up to about 40 m.p.h. A little experimental work might determine the proper operating speed for comfortable riding over that stretch of road with cars having modern suspension.

W. E. ENGLAND[4]:—We drove over that road at an average speed of about 50 m.p.h., and were running from 55 to 60 m.p.h. much of the time. There were two persons in the front seat and one in the rear, and my opinion and that of the men who rode with me was that the road was very good.

I do not think it is true that the American people still drive as fast as they can. They go about 45 m.p.h. at their top speed. In Canada I think the average speed when touring is about 35 to 40 m.p.h.

PRESIDENT W. G. WALL[5]:—Do our cars ride better today than they did in the past, or is it simply that our roads are so much better? I think our cars ride better. It is certainly true that one can ride in a short-wheelbase car today over only relatively smooth roads and have more comfort than he could have had in a long-wheelbase car 10 or 15 years ago.

One of the problems is to decide how stiff the springs should be. Even expert spring engineers often seem to be undecided on this point in suspending a car that is to be produced in quantity, because a great many owners think, if a car frame ever strikes the axle, that something is the matter with the springs, whereas in reality it is very difficult to design springs sufficiently light to give easy riding and still avoid bottoming at a deep hole or an obstruction. Unfortunately, it seems to be impossible to make springs so that they will meet all conditions without the assistance of the shock-absorber. Snubbers and shock-absorbers have certainly done a great deal toward making cars easy-riding.

CAR SUSPENSION NEEDS COMPLETE REVISION

HERBERT CHASE[6]:—One of the possible solutions of this problem is the individually sprung wheel. That seems to be the opinion of some of the European engineers, and it seems to me it should be given more consideration than it is being given in this country, so far as I am aware, at the present time. I am told that some of the European cars which have individually sprung wheels have remarkably good riding characteristics, even over roads on which the conventional type of springing is proving quite unsatisfactory. I think we should consider making a complete revision of the spring suspension of American cars. Virtually all our cars have springs of the same type, and it is not certain by any means that the present system of springing is the best possible one. In any case it is a great mistake to assume that it is best. No sane engineer advocates scrapping a well-tried and reasonably satisfactory construction unless a better one is in sight. But this is no excuse for failing to investigate thoroughly constructions that seem to promise superior results.

J. WEBB SAFFOLD[7]:—I rode from Cleveland to Quebec with Mr. England and my impression of the road from Montreal to Quebec was that it is a rather good one. I am interested to observe the number of factors, mentioned by the different speakers, that enter into the question of comfortable riding. The condition of the road probably is the primary one; the car certainly is a secondary element; the condition of the occupant probably is a third factor; and the spring, which has been brought into discussion, doubtless is a most vital fourth element.

Not being connected with any company, I can say that I do not think the kind of wagon spring we now have on automobiles belongs on them, and I believe the use of the shock-absorber is an admission of that fact, because, if we had real suspension, we should not need any shock-absorbers. My opinion is that it is time to do a little fundamental thinking on how an automobile should be suspended. Some extensive research along this line might be well worthwhile.

INDEPENDENTLY SPRUNG WHEELS A SOLUTION

JAMES A. WRIGHT[8]:—Our company has had considerable experience with independently sprung wheels, having run several extensive experiments since 1921. We have numerous patents covering the application of this principle; in all, patents granted, allowed and applications pending, we have 79. This principle is made applicable, not only to motor-cars, but to trucks, motor-coaches and tractors and to the rolling-stock on railroads and tramways. These experiments and practical tests have taught us many things.

The car in which we rode from Montreal to Quebec was built in 1921 and has been driven over 200,000 miles. Both front and rear wheels are independently sprung. We find that cars having independently sprung wheels certainly travel the deeply rutted and choppy roads much better than cars having conventional suspension. With this car we have very low road resistance, and the ratio of unsprung to sprung weight is lower than in a conventional car by approximately 60 per cent. The construction also permits a very nice application of independent-wheel steering.

I believe with Mr. Chase and Mr. Saffold that fundamentally the wagon-spring type of suspension is wrong; mechanically it is terrible. I do not suppose that all will agree with me, but if you could investigate it practically from all angles, noting the operation and setting up the data, perhaps you would. We had to set up our own data from experiments because the action, the stresses, the performance, and everything else are entirely different with our car than with a conventional car.

As the result of our experiments we are convinced that the independently sprung wheel is a solution to most of the problems discussed here; and also to brake problems, as it makes possible an excellent application of both front and rear-wheel brakes and also of a propeller-shaft brake. We are using a propeller-shaft brake on our present car. Our experience convinces me that the engineer and the manufacturer will have to accept independent-wheel suspension sooner or later.

INDEPENDENT SPRINGING

MR. STRICKLAND:—When we talk about hard riding and so forth, a very small percentage of the driving to which cars are subjected is being considered. They are filling 95 to 99 per cent of the needs of the public. Hard riding is very much the exception. That raises the questions: How will the independently sprung wheel

[4] M.S.A.E.—Chief engineer, F. B. Stearns Co., Cleveland.

[5] M.S.A.E.—Consulting engineer, Indianapolis.

[6] M.S.A.E.—Engineer, Erickson Co., New York City.

[7] A.S.A.E.—President and general manager, Saffold Engineering Laboratories, Cleveland.

[8] M.S.A.E.—General manager, Wright-Fisher Engineering Co.; president, Wright Flexible Axle Motors, Ltd., Montreal, Can.

operate under the 95 per cent of the conditions? How will they stand up for 100,000 miles or more? How much complication is there? It is going to be a problem, not only to choose which of the many designs to use, but also to work out a satisfactory design for the extreme conditions. If the principle is fundamentally the best, it will come, but it does not appear to be very near at present.

LEE W. OLDFIELD[9]:—I agree with two of the speakers that the present suspension is fundamentally wrong, even though it works. The company with which I have been connected is now building more than 10 cars per week, which is not a very big production, on individual wheel suspension. We have never had any sign of difficulty with our suspension. We are not concerned about patents. Our suspension is cheaper to build than any other suspension of which we know. We have operated more than 200,000 miles experimentally and know of nothing wrong with individual-wheel suspension.

JOSEPH A. ANGLADA[10]:—May I recall the Lansden Co.'s application of helical-spring suspensions to the electric ambulances built for New York City? These vehicles were fitted with triple helical springs near each end of each axle and with shock-absorbers of the Hartford type. Tests of these vehicles showed that the power required to propel them, compared with the power required for comparable vehicles fitted with conventional leaf-springs, was less for the helical-spring-suspension vehicle. The riding-qualities of these Lansden ambulances were very pleasant. These were relatively slow-speed vehicles capable of running about 25 m.p.h.

Another type of automobile, fitted with helical-spring suspension, was Walter Christie's front-drive racing car. It rode very well on the road and on rough dirt race tracks.

It might be advisable to think about departing from what almost everyone has been doing, and perhaps evolve a cheaper form of suspension than our present leaf springs to give equally good riding-qualities; or, if we are to continue to use leaf springs, to put more money into them and use a greater number of thin leaves, worked through a greater range of maximum deflection.

EFFICIENT SHOCK-ABSORBER WOULD CHECK REBOUND

J. E. HALE[11]:—I wonder why we continue to use the term "shock-absorber" to describe the instruments we all have in mind. I think they should be called "rebound checks" or "energy dissipators." Technical analysis shows that three elements in a car absorb the shocks. These are the tires, the vehicle springs, and the springs in the seat cushions. Shock-absorbers are attached to the axles and the frame to check the rebound of the springs. In some cases valves or flappers are introduced in the seat cushions to check the rebound of the cushion springs. As shock-absorbers are ordinarily discussed, it is bad psychology to call them shock-absorbers, because they do not absorb a shock at all; they simply check the rebound of the springs. In doing so, they perform a very necessary function.

It has been intimated that we should dispense with rebound checks, but I feel that, if somebody can design, develop and manufacture rebound checks that will be much more efficient than even the best we have today, that is what we need. I think we need weak springs, well oiled, and if we can become accustomed ourselves and induce the car owners to become accustomed to letting the frame strike through occasionally—realizing that occasional striking through does not hurt them, and that they get with the easier springs a very much better ride—we shall have comfort in even the automobiles fitted with the older so-called wagon-type of spring.

F. G. WHITTINGTON[12]:—The reason we call the devices shock-absorbers probably is that many firms use the terms "rebound check," "snubber" and so forth as trade names, and we therefore fell into the habit of calling them all shock-absorbers. I think that the term "shock-absorber" describes the function of the rebound check. If the motion of the car is checked to slow up the spring action just prior to striking through, the counter effect is not so serious. It is the rebound of the springs after they have been fully depressed that we want to check.

SEMI-ELLIPTIC SPRINGS NOT SO BAD

TORE FRANZEN:—We do not have wagon suspension today. We have something far superior to what used to be wagon suspension. Our springs are long enough to permit sufficiently large deflection. We have wonderful material that no wagon maker ever dreamed of having. We have long life in our springs. The fact that we are using semi-elliptic springs almost throughout the whole industry is no doubt due to the facts that they are extremely simple to apply and can perform the duties of radius-rods and torque-arms.

The coming of the coil spring no doubt is possible. The relation between torsional and bending elasticity should be taken into consideration. For torsion we are using a polar moment of inertia of only 12,000,000 compared with 29,000,000, or Young's modulus, for bending; hence, we have a vastly different efficiency for the same amount of material and the same stress.

The weight of a leaf spring is approximately twice that of a coil spring for the same work and safe stress, yet the application of a coil spring in car suspension becomes a difficult mechanical problem.

So long as we use steel, it is not possible, I dare say, to make a satisfactory suspension without an energy-dissipating device. We can think of other materials of which to build our springs; for instance, rubber, which has a peculiar elasticity curve. The hysterisis "loop" of rubber is enormous when compared with that of steel. Perhaps we can use gases, or some other material in connection with our suspensions. These thoughts are only dreams, however.

The individual wheel-suspension may be coming. I saw it on two cars in Europe. I was not particularly impressed with the riding-qualities of one of them. I am certain that the American public would not take to it at all. The other is known in this Country and is very interesting, but enormously expensive to build. The making of the Lancia suspension was described recently in the *American Machinist*, and I think it took three issues to show how difficult it was to manufacture that particular suspension. So far as I know, that is the only one that has been used for any length of time and really has a history.

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[9] M.S.A.E.—Design engineer, Package Car Corp., Chicago.

[10] M.S.A.E.—President, Anglada Motor Corp., New York City.

[11] M.S.A.E.—Manager, development department, Firestone Tire & Rubber Co., Akron, Ohio.

[12] M.S.A.E.—Chief engineer, Stewart-Warner Speedometer Corp., Chicago.

Designing the Dual Valve-Spring

By A. MOORHOUSE[1] AND W. R. GRISWOLD[2]

SEMI-ANNUAL MEETING PAPER — *Illustrated with* PHOTOGRAPHS AND DIAGRAMS

BECAUSE of the increased engine-speed and the limitations of progress by the previous method of designing valve-springs, Packard engineers entered upon fundamental studies of valve-spring behavior and of the influence of stress range upon durability. Various theories of the dynamics of valve-spring surge were investigated, and one was found which seems to agree fairly well with the observed phenomena. Jumping of valve push-rods and spring failures that could not be explained by the static analysis of spring design are accounted for by the dynamic analysis, which serves as an improved basis for design.

Finding it impossible to design a single spring to meet the conditions, within the space limitations, a double spring with interlaced coils was designed.

Descriptions are given of the provision for mounting the ends of the springs and the methods of assembly and inspection. The dual springs are said to have been in use for more than a year on manufactured cars and on a test engine that has been operating day and night, without a single failure.

RATIONAL analysis was combined with experimental verification in the development of the Packard dual valve-spring, shown in Fig. 1. Breakage of valve-springs always has been a more or less mysterious problem, because it occurred in many designs in spite of normal stresses at the valve-open and valve-closed positions which were, according to existing fatigue-data, amply safe for long-life expectancy. Other factors than those of stress long have been suspected as the cause of breakage; but the materials have suffered most of the blame for valve-spring fractures, in the absence of known factors other than the quality of the steel and mechanical defects in the wire stocks.

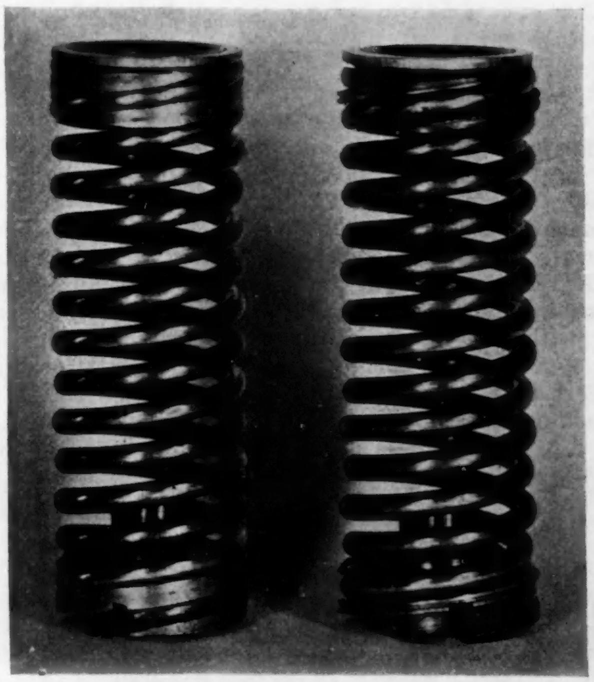

FIG. 1—PACKARD DUAL VALVE-SPRING

At the Left Is a Complete Spring; at the Right an Assembled Spring before Roll-Swaging the Fittings

Conditions have progressed steadily in a way to aggravate trouble with valve-springs and to make more difficult the solution of the problem. The demand for livelier cars—commonly met with high axle-reduction—together with higher driving-speeds, have resulted in a two-fold increase in engine speeds, until top speeds of about 3600 r.p.m. are not rare.

Typical experience has been, during this transition period, something like this: Each time its speed has been raised, the engine has been found to have a bad valve-clatter at some speed below the maximum at which it might be expected to run, or else the valve mechanism has been found to suffer permanent damage from extended periods of driving near the top speed of the car.

The step generally taken to overcome these troubles is to try valve-springs that exert more force to close the valve, at the same time often changing the wire size to reduce the maximum stress. This procedure finally reaches a limit beyond which further steps produce no good effects.

It has been known for some time among engineers that, during the dwell period while the valve is closed, the center coils of the spring may surge back and forth through a considerable amplitude at certain more or less critical camshaft-speeds. This phenomenon has been associated by various investigators with the occurrence of spring fracture, but no satisfactory explanation has been advanced.

A common basis of design at present is to try to make the natural frequency of the valve-spring high enough so that resonance with the motion of the valve-gear does not produce violent vibrations within the desired speed-range of the engine. This procedure requires stiffer springs and introduces other troubles, either with single springs or with two springs, one within the other. Further, even this procedure does not always produce beneficial results; sometimes spring breakage is increased. The higher stress-ranges have caused failure in numerous designs that were expected to give good results. Instead of recognizing the fault of too high stress-range, the blame has been placed upon the valve-spring material. In many cases, the very

[1] M.S.A.E.—Chief engineer, Packard Motor Car Co., Detroit.

[2] M.S.A.E.—Engineer in charge of analysis of design, Packard Motor Car Co., Detroit.

best grades of alloy steel have been specified, together with special processing such as hand-tempering and grinding the surface of the wire to eliminate defects. While some of these steps may have improved conditions, they do not constitute a complete remedy.

Some time ago, in the Packard laboratories, an attempt was begun to make a complete rational analysis of the entire valve-spring problem, with the object of determining the principal factors involved in spring operation for long-life expectancy. The analysis seemed to divide itself into the following two general questions:

(1) For any given material of a reasonable degree of uniformity, what can be the normal stress-range for a life exceeding say 100,000,000 cycles of stress?

(2) What are the effects of the dynamics of the valve-gear in producing secondary stress?

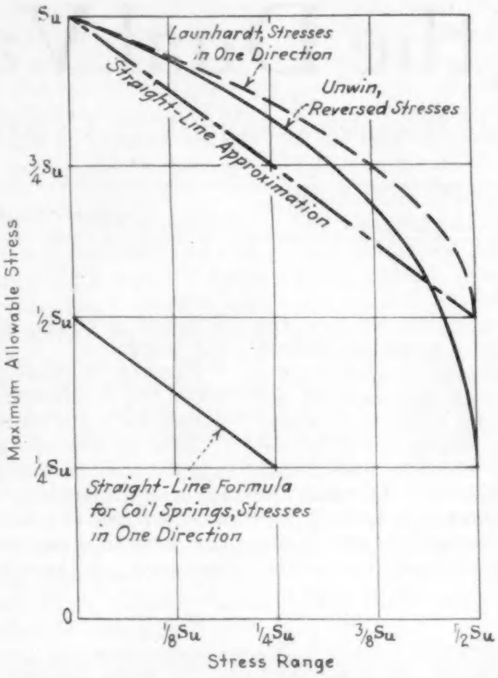

FIG. 2—RELATION BETWEEN STRESS RANGE AND ALLOWABLE STRESS

Questions concerning material were directed to an analysis of products already on the market and to methods of testing for uniformity. The solution of the problem, as we analyzed it, must be based upon the premise that, with all the elements of the problem determined and with a certain degree of uniformity of material reasonably to be expected, it must be possible to work out a spring design with satisfactory life-characteristics.

We have every reason to believe that fatigue failure under repeated stress-cycles would occur at lower maximum-stresses as the stress range is increased. As far back as 1870 Wöhler had found this to exist. Unwin, for instance, quotes Gerbér's formula[3], based on Wöhler's experiments, as follows:

$$S_{max} = \tfrac{1}{2}\triangle \sqrt{(S_u^2 - k\triangle S_u)} \qquad (1)$$

where k is a constant depending on the material, S_{max} is the maximum permissible stress, S_u is the breaking strength, and $\triangle$ is the total stress-range. Unwin says that the value of k increases with the hardness of the material and is from $1\frac{1}{2}$ to 2 with ductile iron or steel. The work of more recent investigators also shows that some such relation exists.

Existing formulas developed from fatigue experiments, we felt, could not be applied to determine permissible stresses for valve-springs because, in most cases, the experimental work was done under conditions different from those existing in valve-springs. However, one conclusion—that is, that the maximum permissible applied stress in a piece of material decreases as the stress range increases—seemed fairly sure to be somewhere near the truth. To determine definitely the relation between maximum stress and stress range for a variety of springs made of various selected materials would require program of fatigue testing extending through several years and requiring thousands of tests to be certain of the results. Therefore, it was decided to assume a relationship derived from existing information and then verify the assumption by experiment. This procedure seemed logical, since it would be necessary finally to verify the truth of our complete analysis in any case by testing the ultimate designs.

In Fig. 2 are shown the two curves representing a

[3] See Testing of Materials of Construction, third edition, p. 388; and Elements of Machine Design, part 1, 1909, p. 39; both by W. Cawthorne Unwin.

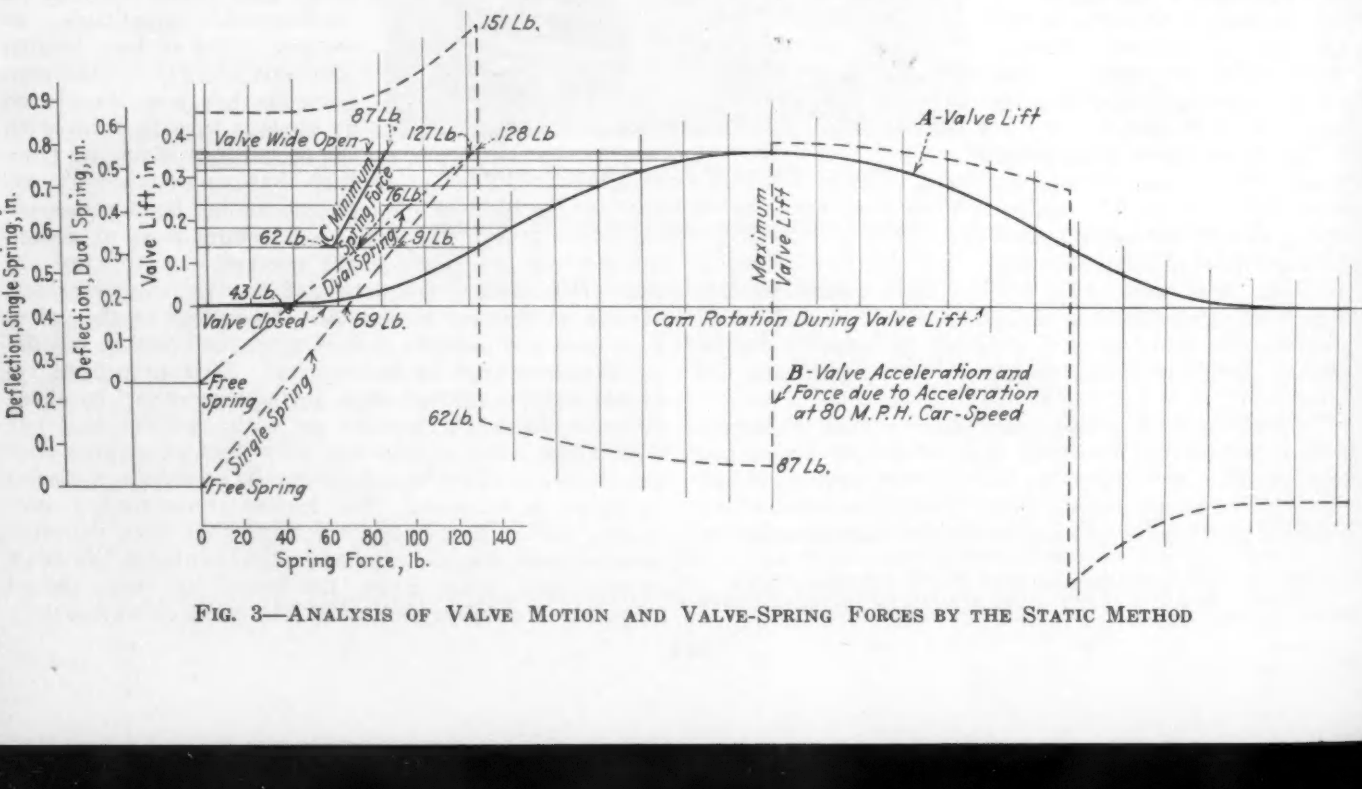

FIG. 3—ANALYSIS OF VALVE MOTION AND VALVE-SPRING FORCES BY THE STATIC METHOD

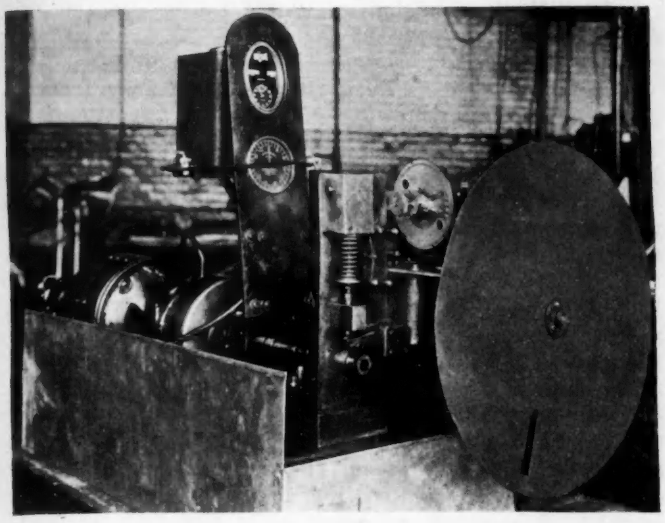

FIG. 4—SPRING-TESTING APPARATUS, WITH STROBOSCOPE

relationship of maximum stress and stress range, the full-line curve being based on formula (1), from Unwin, and the dash-line curve on Launhardt's empirical formula[4] for stress ranges varying from zero to the maximum. The upper straight-line curve approximately expresses the formulas of both Unwin and Launhardt for a large portion of the range. Using the same notation as before, the Launhardt formula can be written

$$S_{max} = \tfrac{1}{2} S_u [1 + (S_{max} - \triangle)/S_{max}] \qquad (2)$$

The elastic limit in torsion is approximately 75 per cent of that in tension, the proportion of bending stress to torsion stress increases with stiff springs, and fatigue experiments show the life to increase about ten-fold for each reduction of 50 per cent in operating stress. Taking these facts into account, we estimated that, to get a life expectancy of 100,000,000 cycles before fracture, the relation of stress range to maximum stress should be approximately that shown by the lower straight line in Fig. 2. This relationship was used as the basis for designing the experimental springs.

THEORIES OF VIBRATION

The next phase of the problem was that of analyzing the dynamics of the valve mechanism. A diagram was made, as shown in Fig. 3, with a curve *A* in which the lift of the valve for a tangential cam was represented by ordinates, the abcissas representing the angular rotation of the crankshaft. Another curve, *B*, is shown, to represent the acceleration of the valve, and the same curve represents the acceleration and deceleration forces acting upon the valve during the opening and closing, just sufficient to maintain the motion of the valve.

At the point of tangency between the flank and tip radius of the cam, the acceleration force changes from 151 lb., in the example taken, to a deceleration force of 62 lb., the greatest deceleration being 87 lb., at the point of maximum lift. The acceleration diagram for the closing of the valve shows the same figures as for corresponding points of the opening, except that acceleration figures become deceleration, and vice versa.

[4] See Strength of Materials, first edition, by James E. Boyd, p. 286.

The highest spring-force required is 87 lb., at the tip of the cam. If a spring could be depended upon always to function exactly according to its static-deflection curve, as it would if it had no weight, it would be necessary only to design the spring so as to prevent throwing of the valve at some arbitrary maximum speed, say at 5 or 10 m.p.h. faster than the top speed of the engine, to provide an allowance for friction during the closing of the valve. In this example a spring with a straight-line characteristic curve *C*, passing through points representing pressures of 62 lb. at the ends of the straight flanks of the cams and 87 lb. at the maximum-lift point, should be suitable for actual speeds of about 75 m.p.h. The higher force of 151 lb. is exerted by the cam against its follower at the end of the acceleration period as the valve rises, and by the follower on the cam at the beginning of the deceleration in closing. This generally is designated as static analysis, because only the static force and deflection characteristics of the spring are taken into account, and it would be sufficient only if the spring were without weight when operating.

Actually, such a spring would prove a hopeless failure. The inadequacy of the static analysis is illustrated by the design of a spring that should have been suitable for a speed of about 98 m.p.h. This spring was designed so that the stress range and the maximum stress were exactly in agreement with the curve previously given in Fig. 2, representing in this respect the most efficient design possible. The loads were 91 lb. at the tangent point and 127 lb. at the maximum-lift point. Experience with this spring in service was punctuated with numerous failures, while the stroboscope shown in Fig. 4 revealed other deficiencies and

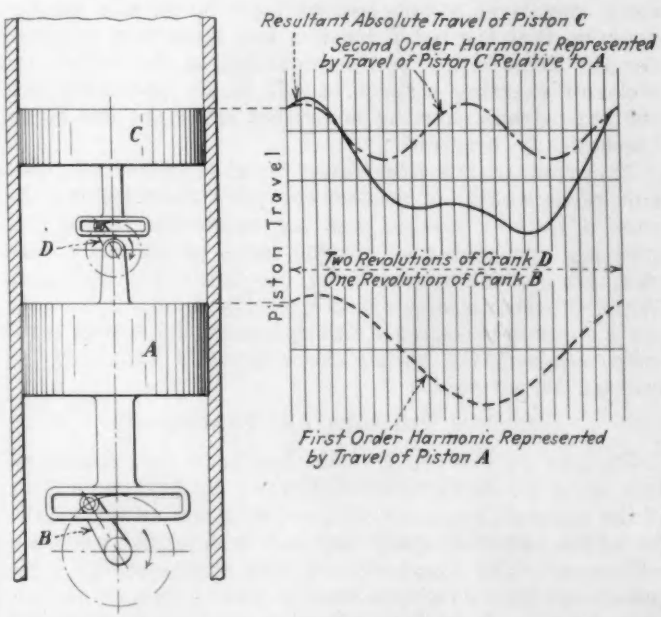

FIG. 5—MECHANICAL REPRESENTATION OF COMPLEX HARMONIC MOTION

Piston *A* Is Reciprocated by the Harmonic Crank *B*; Piston *C* Is Reciprocated by Harmonic Crank *D* Mounted on Piston *A* and Rotating at Twice the Speed of *B*. The Lower Curve at the Right Shows the Harmonic Motion of Piston *A*; the Upper Dot-and-Dash Line Shows the Motion of *C* Relative to *A*, or the Absolute Motion When *A* Is Held Stationary. The Solid Line Shows the Resultant Absolute Travel of Piston *C* When Both Cranks Are Operating

partly explained why heavy spring-force allowances are required to assure proper valve-action if the static method of design is employed. This spring, observed through the stroboscope, showed oscillations during the dwell period at the following camshaft speeds:

At 900 r.p.m., oscillation began.

From 1000 to 1200 r.p.m., the oscillation grew in amplitude.

At 1350 r.p.m., came a very bad period, with noise and clatter, of seven complete oscillations per revolution of the camshaft.

At 1400 r.p.m., the gear was quiet.

At 1450 r.p.m., oscillations began again at a rate of seven per revolution.

At 1600 r.p.m., oscillations were still occurring at a rate of seven per revolution.

At 1650 r.p.m., corresponding to 75 m.p.h., the roller jumped from the cam, with noise and clatter and vibration of very large amplitude, at a rate of five oscillations per revolution.

With this spring exerting a force of 127 lb. at the maximum lift of the valve, the roller-follower jumped the cam at an engine speed of 3300 r.p.m., although only 83 lb. of spring force is required at this speed, according to the static analysis. This difference of 44 lb. represents an allowance for friction of approximately 50 per cent, added to the spring force seemingly required. Such an allowance does not seem reasonable, as the friction cannot approach this amount. So great a discrepancy needs some other explanation than that of friction. The observed surging of the spring-coils, particularly the violent surges at the speed at which the roller jumped from the cam, was sufficient to explain the cause for the need of the heavy spring-force. The surges, that is, the dynamic forces of the vibrations, negatived a sufficient part of the normal spring-force so that the net force was less than that required for the deceleration and acceleration of the valve. Instead of exerting a force of 127 lb. at maximum lift, the spring was exerting somewhat less than the 83 lb. theoretically required.

To prove that a reasonable increase in spring pressure alone would not prevent the roller from leaving the cam, a 7/64-in. washer was put under the spring, increasing the maximum spring-force to 145 lb. With this, the roller jumped from the cam at 1700 r.p.m. While this increase in speed of 50 r.p.m. should account for a 6-per cent increase in the amount of spring pressure required, the spring force actually had been increased 14 per cent.

Previous Theories Are Inadequate

Surging of the center coils has been the subject of treatment by various investigators. Ricardo says that, if the natural frequency of the spring is a simple multiple of the camshaft speed, say 2, 3 or 4 times, resonance will occur. The frequency of this same spring, computed by Ricardo's formula, is 13,200 per min. but, according to these data, there is resonance when the frequency is 15 times the camshaft speed and absolutely destructive effects when it is 8 times the camshaft speed. The stresses caused by the surging of the coils during the dwell period, however, could not account for the spring failures, although they could explain the short life with continued running at the roller-jumping speed. Obviously, Ricardo's statement is not complete, and further explanation is needed.

The formula commonly used for computing the frequency of the valve-spring is

$$N = k\sqrt{(R/W)} \qquad (3)$$

where k is a constant, N is the frequency in vibrations per minute, R is the rate of action of the spring in pounds per inch, and W is the weight of the spring in pounds. This formula gives the frequency of vibrations for two nodes, which is the kind of vibration which occurs when the center coils surge back and forth while the end coils appear to be stationary.

Various authorities give different values for k; Ricardo gives the value of 513, others give values nearly the same, and some give values as high as 588. However, if N, determined by either computation or experiment, is definitely known, then, according to the same theories, the product of the camshaft speed times the number of oscillations per revolution of the cam should be constant for all the critical speeds of the spring, if it is excited by a periodic force. Two methods of analysis are possible for this. In the first, the cam motion for 360 deg. of cam travel, or one revolution of the camshaft, is considered as a periodic motion, the period of which is the time of one revolution of the camshaft.

A Study of Harmonics

Any periodic motion can be regarded as a complex harmonic motion and resolved into a series of simple harmonic motions of ascending frequencies. This is illustrated by Fig. 5, showing two pistons, the lower one, A, moved up and down by the lower harmonic crank B revolving at a constant speed, while the upper piston, C, is moved in a similar way, relative to the lower one, by crank D, carried on A and running at say twice the speed of B. The motion of the lower piston is represented by a harmonic curve of the first order. The motion of C relative to A, or the absolute motion with A held at rest, is a harmonic of second order, as shown by the curve so marked. The movement of C, with both cranks running, is obviously the sum of the motions of the harmonics of the first and second orders and is represented by the curve of resultant travel of piston C. Any number of harmonic cranks can be arranged in series, and the resultant motion of the uppermost piston necessarily would be the summation of the motions from all the individual cranks. Conversely, periodic motion can be dissolved into a series of simple harmonics, by Fourier's analysis.

Such an analysis for the cam used in the investigation appears in Fig. 6, in which the motion of the valve is dissolved into 12 harmonics of increasing order. It will be observed that the amplitude of the motion, in general, decreases as the order of the harmonic increases, but some of the harmonics were of an amplitude too small to draw; thus, harmonics of the sixth and tenth orders do not appear.

According to the laws of resonance and the hypothesis here under consideration, a state of resonance should exist whenever the speed of the camshaft multiplied by the order number of the harmonic becomes equal to the natural frequency of the valve-spring, for then the period of that harmonic is equal to the period of the spring. Also, according to this hypothesis, the following conditions should exist:

(1) The amplitude of the vibration of the spring should be proportional to the amplitude of the harmonic in resonance.

(2) No sixth or tenth-order vibrations should appear.
(3) The critical speeds should be sharply defined by the exhibition of noise or rattle.

Testing the Hypothesis

To determine the truth of this hypothesis, a large spring with a low rate of action and a computed frequency of only 4650 was made up and tested in place of the standard valve-spring, to slow down the oscillations and increase their amplitude. The first oscillations were noted at 600 r.p.m., the spring vibrating with eight oscillations per revolution of the camshaft; at 700 r.p.m. there were seven oscillations; 900 r.p.m. was a critical speed, with five oscillations per revolution and with noise; at 1000 r.p.m. the spring was quiet and there was no rattle; at 1100 r.p.m. the spring rattled again at a critical speed, with four oscillations; and at 1300 r.p.m. the roller jumped, the spring vibrating with three oscillations.

The product of the number of oscillations times the camshaft speed varies from 4400 to 4900, which roughly agrees with the calculated frequency of 4650. The critical speeds were more or less sharply defined, and it will be noted that no sixth-order critical appeared. These results tended to give the hypothesis considerable support.

However, the behavior of a large number of single-coil springs, among them the one previously mentioned, did not correspond to the behavior to be expected according to this hypothesis. In particular, the recurrence of oscillations of the same frequency at a higher speed after passing through a quiescent period tended to refute the hypothesis, and similar inconsistencies were observed with other springs tested.

In the second possible analysis, only the harmonic components of the valve-lift period are considered. The hypothesis is that a harmonic of the valve-lift motion furnishes an impulse that starts in the spring a vibration which continues after the harmonic impulse is over, until the next harmonic impulse occurs. This analysis is shown in Fig. 7 in which are shown the valve-lift curve and the curves representing the har-

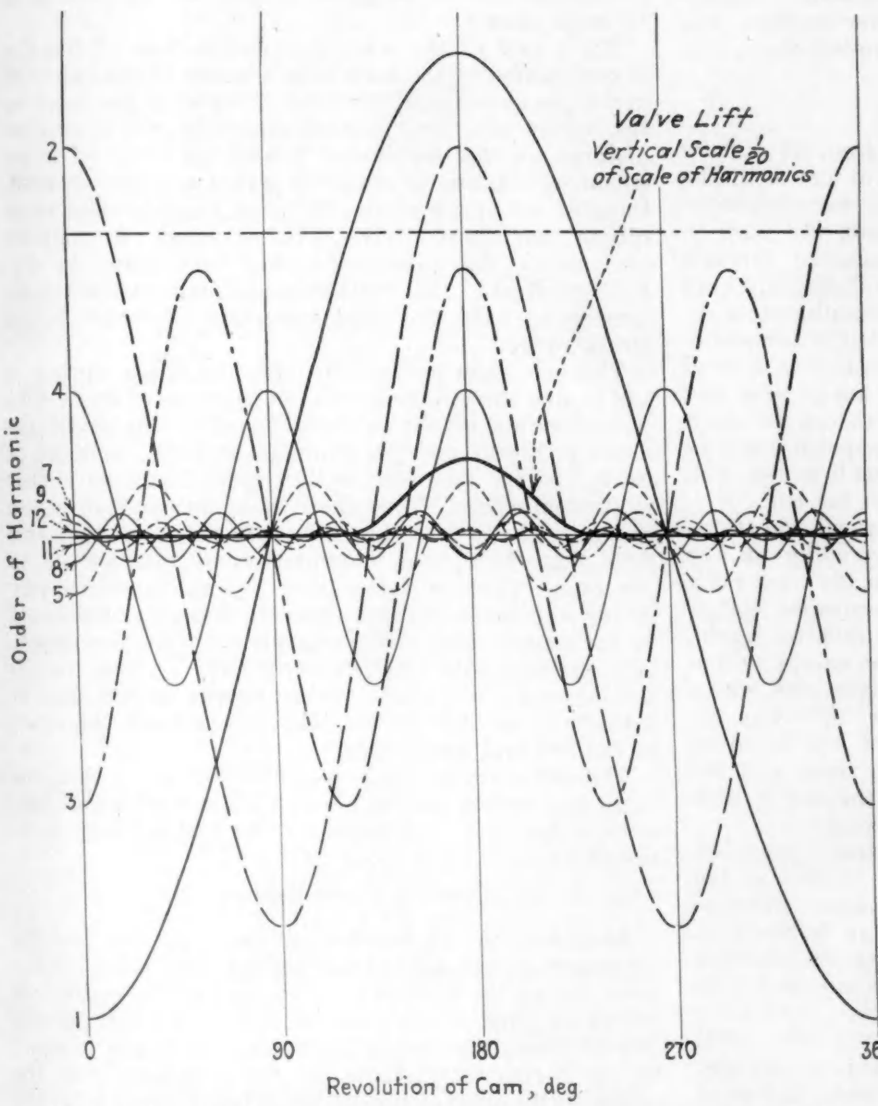

Fig. 6—Harmonic Analysis for One Revolution of the Camshaft

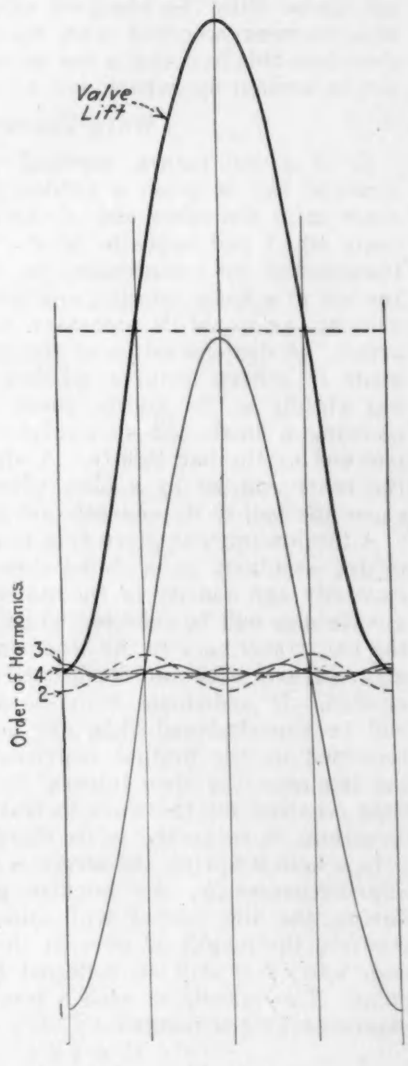

Fig. 7—Harmonic Analysis for Lift Period of the Cam

monics of the first, second, third and fourth orders. Since the valve-lift period extends over 116 deg. of camshaft rotation, the orders of these harmonics must be multiplied by 3.1 to be in the same order as those in the previous analysis; consequently, the first-order harmonic becomes approximately a third-order harmonic, and the second becomes a sixth harmonic, and so on. If this hypothesis is correct, and if the damping in the spring is very small, the critical speeds should be 385, 500, 750 and 1500 r.p.m. These speeds obviously do not agree with the observed critical speeds. Similar disagreement occurred with many other springs, and therefore this hypothesis has no basis unless the spring can be excited by unharmonic forces.

Wave Theory

It is a well-known physical fact that, if a long straight bar is given a sudden push at one end, the reaction at the other end of the bar is not simultaneously equal and opposite to it. Instead, the push is transmitted by compression in the material through the bar at a finite velocity, and not at an infinitely high velocity, as would be necessary for a simultaneous reaction. A demonstration of this fact that is commonly made in college lectures consists of clamping a steel bar rigidly at its middle point in a heavy vise and allowing a small ball suspended on a thread to touch one end of the bar lightly. A sharp impulse given to the other end, as by a blow with a small mallet, will cause the ball to fly violently away from the bar.

A torsion impulse given to a round bar will be transmitted similarly at a finite speed, depending on the elasticity and density of the material in the bar. Such a wave also will be reflected when it reaches the end of the bar, travel back to the other end, be reflected again, and so travel back and forth until all the energy is dissipated. If additional impulses are given, the waves will be superimposed upon one another, in a way determined by the mutual relationship of the speed of the impulses, the time interval between them, and the time required for the wave to traverse the bar in both directions in returning to its starting point.

In a helical spring the stress is principally torsional, and, consequently, the impulse given to the spring during the lift period will cause a stress wave to traverse the length of wire in the spring to the fixed end, whence it will be reflected back to the starting point. The velocity of such a wave in a spring can be expressed by the formula

$$V_s = k\,d/r \qquad (4)$$

where d is the diameter of the wire; k is a constant, depending upon the material; r is the mean radius of the spring, and V_s is the velocity of the stress wave.

The velocity with which the impulse is applied is equal to the velocity of the valve lift and therefore can be represented by the velocity curve of the cam-lift period. If T represents the cam-lift period, the distance traveled by the wave along a very long spring would be V_sT; and if $2L$, representing twice the length of the wire in the spring, is greater than V_sT, the wave will not traverse the spring back to its starting point before the impulse is over, and therefore will be superimposed upon the new wave just starting.

By combining all of the superimposed waves, the dynamic forces in the spring can be determined. The diagrams for two springs operating at a camshaft speed of 1765 r.p.m. are shown in Fig. 8. One is the same single-coil spring used in previous illustrations, and the other is the Packard dual spring. Curves are shown of the valve lift, valve velocity, spring force required to make the roller follow the cam, and of the static spring-forces for both springs. The dynamic forces at the cam, or lower, ends of the two springs are indicated by the heavy full lines, and those at the fixed, or upper, ends by broken lines, all clearly marked. For convenience in plotting, these are drawn to different scales, but the values given enable the comparison to be made clearly.

The travel of the wave during the time of impulse is represented by the horizontal distance of the valve-lift period, as shown, and the time of travel of the wave up the spring and back is represented by the horizontal distance marked *Equivalent Length of Wire*. The residual oscillations or standing waves are very evident, those of the single spring being of much greater magnitude than those of the double spring. A complete analysis of the wave theory has been given by Dr. Wilhelm Hort[5]. This method of analysis provides some interesting data, the most important of which is the stress range.

The maximum spring-force for the single spring is 142 lb. and the minimum is 54 lb., a range of 88 lb. The corresponding maximum force based on the static analysis is 127 lb. and the minimum is 69 lb., a range of 58 lb., which was just within safe limits with that maximum stress. Thus there is an increase in stress range to 52 per cent above the safe range, at the same time that there is a maximum-stress increase of 12 per cent. This indicates short life and explains why spring failures occur, even though computations based on the conventional static analysis show the stresses to be consistent with long-life expectancy. These computations make the single spring appear better than it actually is, as they do not take into account the effect of the residual oscillations.

The minimum spring-force of 54 lb. is less than the force required to maintain roller contact with the cam, a fact that is corroborated by the test already mentioned.

Conditions of Resonance

According to this method of analysis, two possible conditions of resonance exist between the travel of the wave during the time of the impulse and the equivalent length of wire, if residual oscillations do not persist. One of these exists when the equivalent length is equal to the horizontal distance on the diagram from the origin to the intersection of the velocity curve with the base of the lift curve; that is, the point at which the velocity changes from positive to negative, at extreme valve-lift, *OB* on Fig. 8. The other obtains when the equivalent length is the same as the distance from the beginning of the lift to the point at which the acceleration of the valve changes to deceleration, at the point of tangency of the flank of the cam with the top radius, *OA* in Fig. 8. Springs having equivalent lengths within the range of these two extremes will suffer residual oscillations, and the spring forces will vary greatly from those calculated by the static method. In other words, when the equivalent length lies between *OA* and *OB*, on Fig. 8, the spring will have short life.

This relationship changes with the speed of the camshaft. If we assume a slower speed, for instance, the

[5] See Technische Schwingungslehre second edition, 1922, p. 503.

travel of the wave during the time of the impulse will be increased, while the time of travel up the spring and back will be the same as before, the result being the same as that of reducing the equivalent length of the spring without changing the speed. When the equivalent length becomes less than OA, the length shown for the Packard dual valve-spring, residual oscillations no longer persist, and the modifications of the static spring-forces approach zero.

Increasing the speed has the opposite effect, as illustrated by the results given for the single-coil spring speeds much lower than the calculated values for single springs and for double springs with closed and squared ends. After much testing it seemed almost certain that the end turns, ordinarily regarded as inactive, were partly active in the transmission and reflection of the stress waves.

Concentric Springs Disappointing

This was shown particularly by the behavior of a double-spring combination in which a smaller spring is telescoped within a larger one. The loads for the valve-

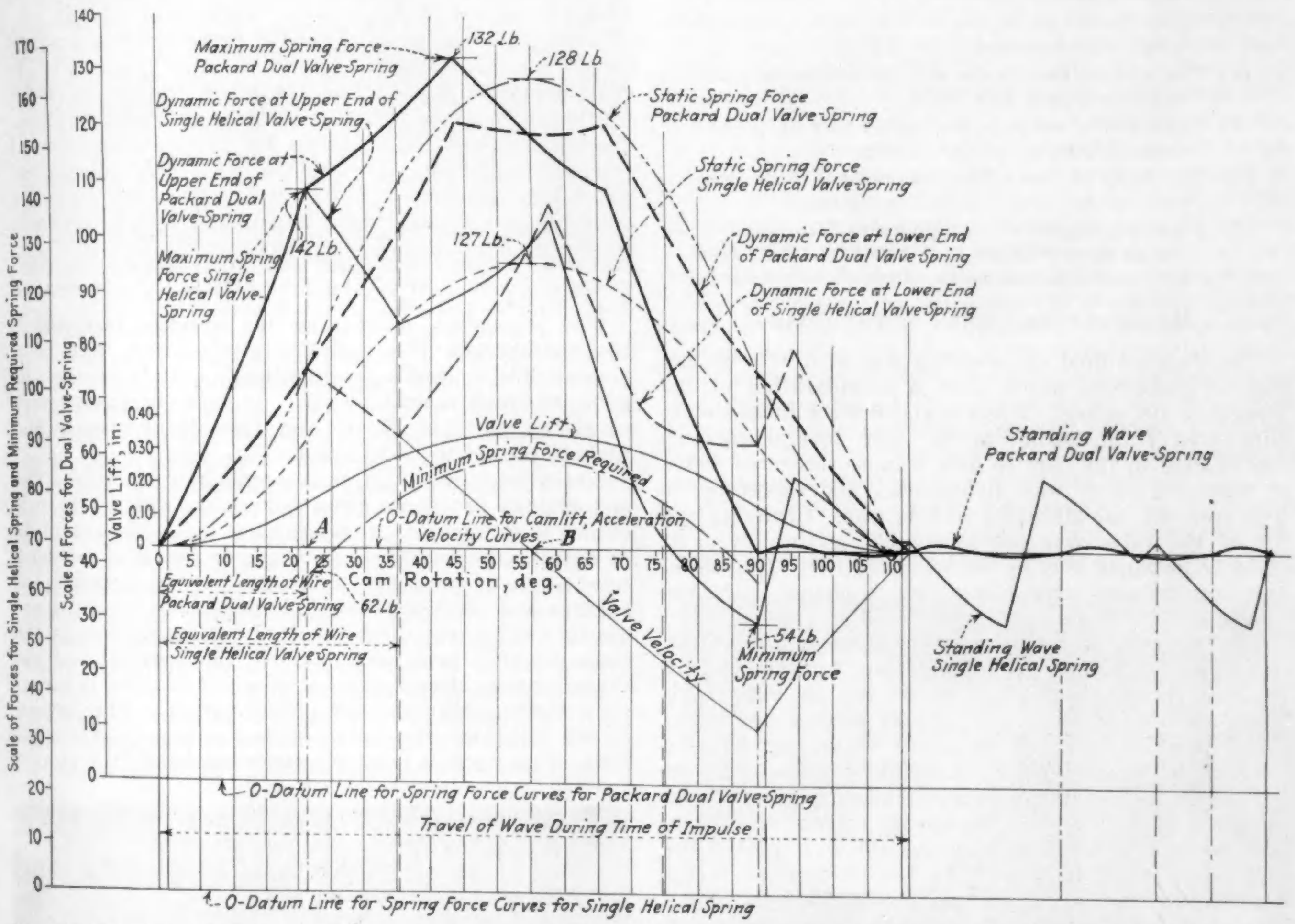

Fig. 8—Combined Dynamic Study of a Single Helical Valve-Spring and the Packard Dual Valve-Spring for One Revolution of the Camshaft

shown. Reducing this analysis to the same form of expression as that given by Ricardo gives

$$1/L = k\sqrt{(R/W)} \qquad (5)$$

where k is a constant, L is the equivalent length of wire, and R and W are the same as in formula (3). As in the other analysis, this indicates that, for desired results, the rate must be as high and the weight as low as possible, so that L is equal to or less than the equivalent travel of the wave during the lift period from the beginning of the lift to the point of tangency of the cam, OA in Fig. 8.

Calculations based on the wave theory, however, were not in complete agreement with the actual behavior of springs tested and observed with the stroboscope. Residual oscillations and resonant vibrations occurred at closed and valve-open positions were 60 and 140 lb. respectively; and the frequency, computed by Ricardo's formula, was 17,400 for the outside spring and 20,000 for the inside spring. According to the wave-theory analysis, this combination should have permitted speeds much higher than the single spring previously referred to, but the roller-jumping speed was precisely the same.

The computations were made on the basis of the active coils only, and the individual springs of the double-spring combination were wound with a variable pitch so that several end coils were closed solid in the valve-closed position. These end coils became partly active when excited by the stress waves. This substantiated what had already been indicated by the factors in the wave theory, that all of the wire in the spring must be considered, and suggested further that the conditions

could be improved by positive provision for making the ends inactive.

As a final summary of all the analyses considered, correlating them with tests of springs of about 25 different designs, including telescoped double springs, cluster springs and a variety of single springs, we postulated the following main points upon which to design a suitable valve-spring:

(1) The value of R/W must be high, or, specifically, the equivalent length of wire must be equal to or less than OA, in Fig. 8, considering all the wire in the spring.

(2) Valve breakage is due to too high a dynamic stress superimposed upon the static stress.

(3) The static-stress range and the maximum stress must be within safe limits.

(4) Unharmonic waves in the spring may excite harmonic vibrations of the spring.

(5) The shape of the valve-lift curve has some influence on the vibrations in the spring.

(6) Load requirements and high valve-lifts make the design more difficult by a two-fold effect, from both high valve-velocity and high stress-range.

Mathematical Design of the Spring

The Packard dual valve-spring was at first a mathematical conception based upon a consideration of the foregoing six points. Items 5 and 6 were immediately eliminated from consideration. For several reasons, any change in the cam to give a more desirable shape of valve-lift curve was undesirable, and therefore no improvement was allowable in this way. Changing the lift of the valve was not acceptable, as improvement could be obtained only by reducing the lift. Therefore, any improvement must come from a change in valve-spring design alone.

Two methods of procedure were open to us: First, choosing an arbitrary speed equivalent to 80 m.p.h., we reasoned that the spring having the highest rate possible to use would be one exerting zero force at the valve-closed position and a force equal to the acceleration force of 62 lb. required to maintain cam-and-follower contact at the point where deceleration begins. Trial calculations showed that the spring load at the valve-open position would then be about 166 lb.; that is, the load range would be from 0 to 166 lb. and the stress range would start at zero stress. Going back to the relationship of stress range to maximum stress, we found that, for such a condition, the maximum stress must not exceed $S_u/4$ and the stress range would be $S_u/4$. Trial calculations quickly showed that it was impossible to obtain the required loads for these stress conditions in a single spring fitting into the space available.

Rewriting equation (2) in terms of the dimensions of the spring gives the formula

$$N = Qd/nr^{\cdot} \quad (6)$$

where d is the diameter of the wire, n is the number of active coils, Q is a constant, and r the mean radius of the spring. Thus the spring having the maximum value for N will be one in which d is largest and n and r are smallest.

For the moment we proceeded with an analysis to determine what would obtain with the assumption of a mathematical spring composed of a number of identical springs, to meet the requirements as to stress and load, no restrictions being placed on the dimensions except that the resulting combination must fit into the space available. First assuming r equal to the radius of a single-coil spring fitting into the space, a series of calculations showed that three springs would be required.

Several objections to a spring with no initial load are apparent. First, some allowance should be made for dimensional variations of the parts; second, an allowance should be made for grinding and reseating the valves; third, an allowance should be made for manufacturing variations in springs; and, fourth, there should be an initial load sufficient to assure full seating of the valve at slow speeds. These calculations did, however, show the boundary conditions of design.

The next step was to determine a suitable spring-design in view of all conditions. Referring to Fig. 8, we determined the equivalent length of wire with which residual vibrations would virtually vanish and obtained, by trial-and-error calculation, the number of identical springs, the dimensions of the wire, the number of coils, and the load and stress conditions meeting the requirements already laid down. Two springs were required.

Construction and Assembly of Dual Valve-Spring

The conception of making the springs intercoiled, like the threads of a multiple-thread screw, had been formed already, but a practical method of fastening the ends required careful study. Various methods were conceived, but that of fastening them in grooves in end fittings proved to be the best.

The present construction is simple and practical. The end fittings are made from bar stock, completely machined in automatic screw-machines, with the exception of cutting the keyway. Both pieces are grooved with two pairs of grooves: deep grooves to receive the springs and shallow grooves to facilitate a swaging operation. The root diameter of the deep grooves is the same as the inside diameter of the spring, and the diameter over the threads between the grooves is larger than the outside diameter of the spring. The bottom fitting functions also as the spring retainer. After the lower fitting comes from the screw-machine, it is slotted

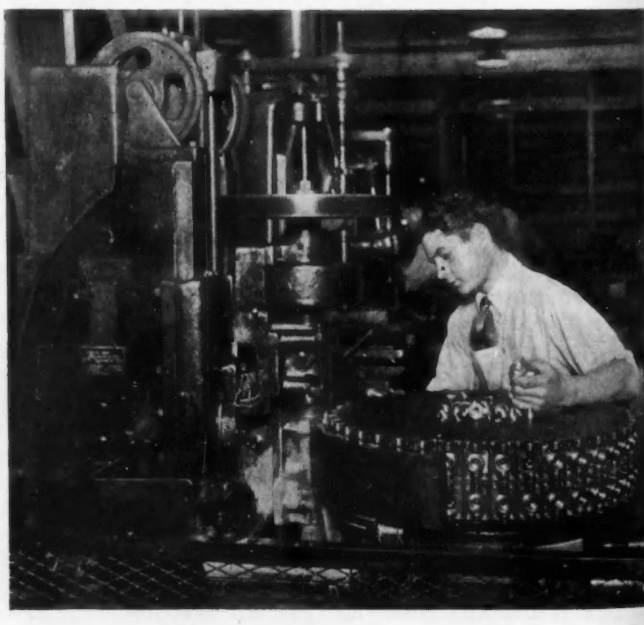

Fig. 9—Milling Key-Slots in Lower Fittings

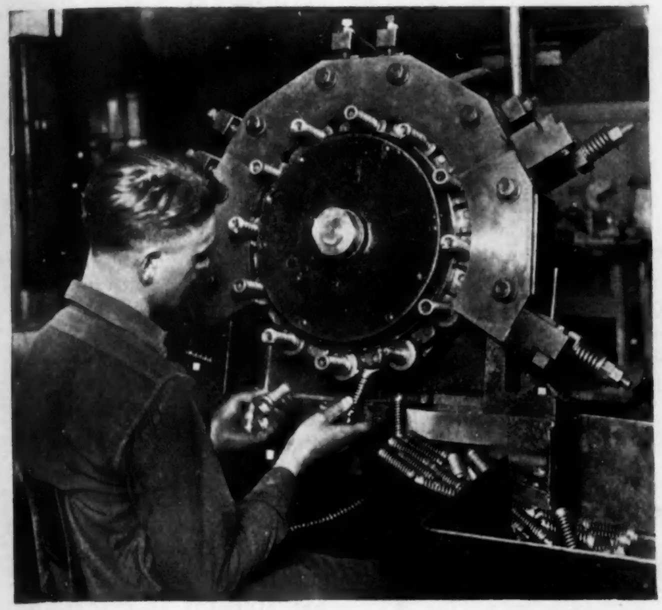

FIG. 10—ROLL-SWAGING FITTINGS ON DUAL VALVE-SPRINGS

in a continuous milling-machine, as in Fig. 9. The upper piece is fitted with a washer that is spun in place.

The assembly begins with screwing the springs into the bottom fitting, which is done by placing the fitting in a small holder that has a key registering with the keyway. The assembler screws one spring into place until the squared end of the wire butts against the key in the holder, the other spring is hooked into one coil of the first spring and is screwed down to the fitting, and the wire is inserted into its groove and screwed down until it touches the key. Then the upper fitting is placed on the other end of the springs and screwed down with pliers. The last operation is the swaging of the threads down around the wire in the grooves, which is done in the machine shown in Fig. 10, in which the fitting rolls between two dies, the distance between which progressively diminishes, along the course of the rolling, until it is equal to the outside diameter of the spring. The springs are tested on an air-operated fixture having fixed stops, which presses the spring down against the scale platform as seen in Fig. 11.

For experimental test, a Packard engine without pistons and connecting-rods was driven by an electric motor. All tests were conducted at speeds between 3000 and 3300 r.p.m. The method of rating life was purely arbitrary. Springs were tested in sets of 16, and the life of the entire set was assumed to be that at which the first spring broke. If no fractures occurred, one set was removed and another set installed at the end of 300 hr. The first wire-stock used was a plain high-carbon wire of medium grade, which proved to be non-uniform in character. Numerous failures occurred within less than 300 hr. Each broken surface, upon metallurgical examination, showed significant defects in the material. Attention was then given to the selection of wire stocks of somewhat better grade.

To eliminate many of the hard spots, seams and internal impurities that are well known to be greatly injurious to spring life, our metallurgical department decided upon the following as a standard test: At least 2 ft. of wire is cut off from each end of each bundle of wire and a section 12 in. long is subjected to a twisting test consisting of seven turns in one direction and a sufficient number of turns in the opposite direction to fracture the wire. The wire must stand at least seven reverse turns, and the break must be a clean square fracture. Longitudinal fractures, hard spots of certain descriptions, and failures of certain kinds are causes for rejecting the whole bundle.

A better grade of plain-carbon wire so selected showed average life of more than 200 hr. in the test described. Very likely the average life would have been more than 300 hr. if each spring had been run to failure. Some time later another plain-carbon stock, showing exceptional results in the twisting test, was adopted. All the sets of springs of this material that have been tested have run the full 300 hr. with no failure.

Results in service have been particularly gratifying. The dual valve-spring now has been in production for more than a year, and not a single spring, to our knowledge, has broken in service. The many thousands of miles of high-speed testing at the Packard proving ground also has never been marred by a spring failure.

Other advantages that have been displayed by this type of spring construction are increased smoothness and quietness of the valve gear at all speeds, particularly at idling speed; elimination of rotation of the valves, which has resulted in an almost complete avoidance of wear upon the valve-seats in the cylinder; general preservation of the valve gear by the elimination of valve clatter and roller jumping; and an absolutely balanced load on the valve-stem, which has reduced valve-stem-guide wear to a negligible amount.

After 1000 hr. on the test engine, the valve-stem clearance had barely changed. This engine has run day and night at high speed for more than one year.

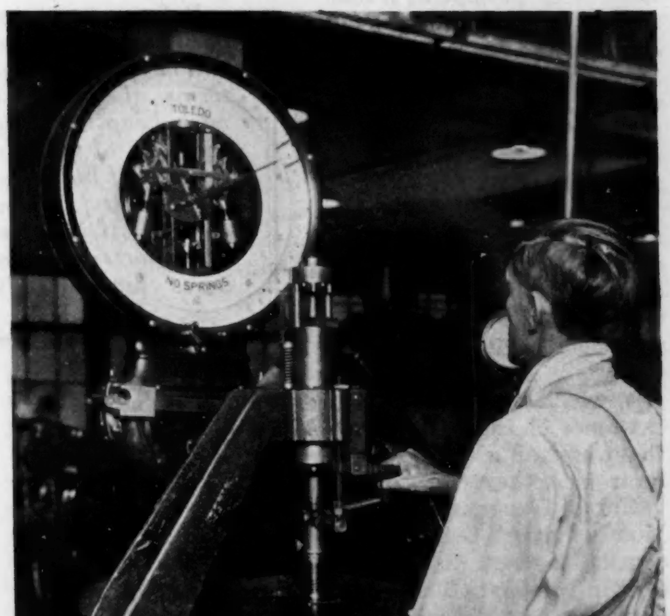

FIG. 11—TESTING FINISHED DUAL SPRINGS

The Engineer as a Business Man

By Norman G. Shidle[1]

Semi-Annual Meeting Paper

ASSIGNMENT of a topic such as The Engineer as a Business Man indicates the feeling on the part of someone that something is the matter with at least some engineers as business men. While one does not necessarily agree with this point of view, the feeling comes that one thing perhaps more than anything else is the matter with the engineer as a business man: Engineers, like most other human beings, are much afflicted with an inferiority complex; but they often seem to be just a bit more afflicted with it than anyone else.

This inferiority complex manifests itself in two ways. It makes some men bluster into all sorts of situations, throw out their chests and say, "That is wrong"; "This is right, we must have it this way"; and makes them try to push themselves forward all the time in an unpleasant, aggressive manner. The other way it manifests itself is by prompting a man to say, "If the management didn't ride me this way"; "If my style wasn't being cramped"; "If the sales department would only do this, what great work I could do in this organization."

One thought is worth stressing. If the men on the engineering staff can get out of their heads the idea that the difficulties they meet in the performance of their tasks are surrounding factors which hedge them in and simply assume that the existence of these difficulties is a normal condition and the overcoming of them is an every-day routine part of their jobs, they will begin to accomplish something.

Harry Tipper, general sales manager of the General Motors Export Co., said some years ago, in reply to a complaint about the difficulties of getting along with certain persons: "These human beings you are working with are just a part of your business problem. You have nothing to get excited about."

It is hard to get this point of view; it takes a long while to understand it and even longer to feel it. There probably always will be times when it seems impossible to achieve the latter condition. Circumstances arise almost every day which the engineer believes hamper him. If they continue to "cramp his style" for a period of years, it is likely that the fault is not that of the sales department, not that of the management, not that of anybody in the company except the engineer himself; because the perfecting of conditions under which he can fulfil his greatest mission is an integral part of the engineer's own job.

The engineer has to be salesman within his own organization, and if he is a poor salesman he is not capable of being the best engineer. If he cannot sell his ideas, he is not capable of convincing the rest of his organization that the ideas are good. Insofar as he fails in that, he fails in a certain part of his fundamental engineering function, because all the abilities a man can have are not worth anything unless he gets an opportunity to exercise them. An engineer's good ideas are just visions until he can, perhaps by the force of his personality or his own participation in the management's viewpoint, get his ideas agreed with by those who are superior to him, or working with him or even under him in the organization. Every idea has to be sold. When the engineer fails in his selling effort, there is no one to blame but himself.

Engineers are much afflicted with an inferiority complex.

If they can get out of their heads the idea that difficulties they meet are factors that hedge them in, and assume that the overcoming of them is a routine part of their jobs, they will begin to accomplish something.

The engineer has to be a salesman within his own organization. Every new idea has to be sold. If he is not capable of convincing the rest of his organization that his ideas are good, he fails in part of his engineering function.

Relative importance of the engineer varies almost directly with his ability and willingness to think and act in terms of general business needs. He must keep thinking ahead of the management, of the sales department and of the rest of his organization.

Authority is never delegated; it is earned. It is not a matter of organization charts; it is one of individual ability to think broadly in a business sense.

This inferiority complex leads to a tendency to blame others for existing conditions which should be altered by the proper fulfillment of the true functions of the engineer. The relative inarticulateness of engineers, for instance, is proverbial; the extent to which it hampers the progress of individual engineers, however, is not so well understood. To be able to express one's self in writing and orally has become almost an essential to success in modern industry, with its large-scale organizations and the resulting necessity for the meeting of many minds on complex problems. To be effective in modern industry, most ideas have to be transferred from one mind to many; only the simplest ideas can be so transferred by means of a blueprint alone. When an engineer fails to impress his organization with a program or a design which he firmly believes to be sound, the fault lies, more often, in the inability of the engineer to express effectively what he has in mind than in the inability of other minds in the organization to understand properly.

[1] A.S.A.E.—Directing editor, *Automotive Industries*, Philadelphia.

Grasp of Business Problems Needed

A valuable suggestion was given by a man who said that the business progress of engineers depends about 75 per cent on their ability as technicians and 25 per cent on the general impression they make in the organization concerning their judgment, their reaction to management problems, and the like. If they realized this, it would be much easier for their immediate superiors to broaden the scope of their activities and to permit their further development. Many times a highly efficient man in an engineering department makes it very hard for his superior to give him greater scope because the man has failed to realize the necessity for contact in the organization, the necessity for trying to understand management problems as well as strictly engineering problems.

Dr. Max Mason, in a recent address, spoke of the swing in educational development from the old idea that scholasticism should not be used commercially, toward the idea of utilitarian culture, and said that the swing of the pendulum has been too great in the latter direction; that a little swing back is necessary. It may be that a similar swing has occurred in the relations between the engineering and the sales departments in the automotive industry. There was a time, years ago, when the technician was all-powerful in the automotive factory; he had to be, for there were only a few men in the Country who could make an automobile that could be depended on to run more than 10 miles without stopping. Gradually, however, the swing through the great period of productive development brought us to the era of intensive merchandising.

In this later stage there has, perhaps, been a little too strong tendency in some instances toward complete dominance by the sales department. But even this tendency is nothing for the engineer to rail against. If that condition has come about to any large extent, it is, perhaps, due as much to the inability of the engineer to sense and understand the necessity for a change of attitude toward his work and for a changing attitude on the part of the management toward the sum total of its operating problems as it is due to any general desire or ability on the part of sales executives to steal the play from the engineering department. Analysis seems to indicate that the relative importance of the engineer varies almost directly with his ability and willingness to think and act in terms of general business needs rather than in the more rigid, and consequently less inclusive, terms of strictly technical activity.

Only a Part of the Whole

The same old inferiority complex, perhaps, is responsible also for the tendency which becomes evident now and then, particularly among engineers and editors, to feel that they belong to a chosen class or profession; that their standards are a little higher, a little finer, a little purer than those of any other group in this crass, commercial world. It seems clear that, from now on, engineering thinking must be business thinking; the engineer must tend to think as a business man. He must not regard his division as one whose function it is to preserve the sanctity of at least a small part of the business of manufacturing. To the contrary, he must think of it and of himself as an integral part of the whole enterprise. Insofar as his ideas are good, he must get them approved. If he fails, he must recognize that it is likely that something is the matter with him or his ideas instead of with everyone else.

Probably considerable over-emphasis is being given to this particular obstacle to success. Certainly many other things besides correction of these various manifestations of the inferiority complex go toward making an engineer successful in business. But it does seem that this particular factor is important enough to warrant rather strong emphasis for the moment. An engineer may well say that there are only three reasons why he cannot, in any given case, get his ideas adopted. One of them is his lack of ability to "sell" them; another is that his ideas may need to be revised to meet conditions about which he was not fully informed when he conceived them; and third, his ideas may just be no good.

Should Keep Thinking Ahead of Others

As the engineer begins to get this business aspect, he will put himself into a positive rather than a negative mode of thought. He must get away from the defensive attitude induced by his inferiority complex. He must try to keep thinking ahead of the management, ahead of the sales department, and of the rest of his own organization. He must try to think of the engineering department in business terms; then he will have his department working on so many good ideas, which fit into the business picture and which have been "sold" to the sales department and to the management, that he will keep the rest of the organization fairly busy working along lines that are thoroughly in accord with his ideas, because he has not given the rest of the organization time to think of other things with which to bother him.

Although there is an element of facetiousness in this last statement, it also contains considerable truth. Anyone who has been in business knows that now and again some department is not functioning to the satisfaction of the management. Everyone has heard of automobile designs that did not "take" with the public. Whoever has observed closely the engineering set-up of an organization whose current design was not selling well must have been impressed with the great number of suggestions the engineering department was receiving from the whole organization. The chief engineer gets innumerable suggestions as to what ought to be done; and very frequently they come from men in the organization whose position makes it necessary to adopt them. That is not the time to start selling ideas; the engineer is then on the defensive and the most he can do, perhaps, is to win his argument and lose his job.

Suggestions sometimes come from some man in the company who has not been so close to the engineering problem as the engineer has been, and the engineer feels annoyed and irritated. "My heavens, how can you do that? What good will it do?" he asks or thinks, and he becomes involved in a whirlpool of argument. Pity the engineer who is in an engineering department when it is slipping, and who does not have a positive and constructive mental approach to his problems, because that department receives an undue number of suggestions from many sources. This is natural, as everybody is trying to think of something that will improve the situation. The engineer who can think ahead, who can see his engineering policy in terms of the business problem of putting the company back on its feet so that it can make money, in terms of that basis of busi-

ness which provides not only his job but his opportunity for service, will be able to evolve ideas which he feels are constructive. They will certainly be ideas under which he will be able to work much more enthusiastically, and probably much more constructively, than if he simply sat back and waited for ideas and suggestions from others as to how to set conditions right from a business viewpoint. We all know that it is more difficult to become enthusiastic about something that comes to us second hand than about something we ourselves have initiated.

Authority Has To Be Earned

An important executive who was talking about another industry made a remark which fits in with this idea of engineering authority and responsibility and the scope of the engineer when he said, in answer to a question as to the proper scope of an engineer, "Authority is never delegated; authority is earned." It does not matter whether one is a draftsman, a chief engineer, a general manager, a vice-president, a president or a chairman or the board, he is always responsible to some person or entity. Whatever authority he acquires must be earned.

That is true for every member of the engineering staff, clear down the line to the bottom. Authority is not a matter of organization charts; range of responsibilities and interests is not a matter of theoretical layout, it is one of individual ability to think broadly in a business sense.

The thought that every engineer should carry with him always is to earn authority for himself.

THE DISCUSSION

President W. G. Wall[2]:—Mr. Shidle certainly hit right from the shoulder and gave us a good deal to think about. There is no question that all engineers could profit by following some of this advice, because, no matter whether one is an idealist or what he thinks from an engineering viewpoint, there is necessarily some utility, some particular purpose, for which the object or design he is making must be used, and he has to think along business lines to realize what is best to put into it.

John A. C. Warner[3]:—It seems to me that, if Mr. Shidle had wanted to make his title more brief, he might have changed it to the simple phrase, "Don't pass the buck." That, after all, is the text that he has covered admirably, and I think we shall all agree that it is a subject and the type of subject we should hear more about. It certainly points out an opportunity that every engineer has to do a little introspective thinking, to try to find wherein he is weak and really attach the responsibility where it belongs. This may seem a severe type of philosophy that Mr. Shidle has preached, but there is this consolation: If we apply it to ourselves, we can realize full well that, even though we take more responsibility than we feel belongs to us, the outcome can only be beneficial to each of us.

It seems to me particularly true that the lack of knowledge of what is going on in other departments is especially noticeable in almost all automotive organizations. Why is it that an engineer is not able to "put over" his pet idea, even though he may have an excellent background of training, practice, test experience, data to work with, and an absolute proof of his point? It is because, in the first place, he does not know enough about his organization as a whole; in the second place, he does not seem to have the ability, in a great many cases, to investigate himself.

Early this year I had an opportunity to work among the sales forces in the field for about three months, making an expedition of about 18,000 miles altogether. I was much interested to find the concept of an automotive engineer that existed among the sales forces in the field. They certainly felt that he was a sleight-of-hand artist and that is about all. They did not believe there was such a thing as an engineer who could talk to ordinary, every-day people so that they could understand him. They felt that an engineer was a peculiar breed of animal that should be put in a class by himself. That, in my opinion, is the feeling that is very general among people who do not really know us well. It is our duty to change it.

Incidentally, Mr. Shidle's paper inaugurates what the Meetings Committee hopes will be a schedule for papers and addresses at future meetings wherein we shall discuss some of the things besides what makes the wheels go round. We feel that, to have a balanced diet at our meetings, we should have some of these other subjects that engineers deal with besides gadgets and that sort of thing.

Business Man Has Reciprocal Responsibility

Edward P. Warner[4]:—One point that stands out with slight divergence from Mr. Shidle's remarks seems to me worthy of further comment. The functions of business can be arranged for the most part under the two general headings of psychology and economics. Mr. Shidle dealt largely with the opportunity of the engineer to develop his understanding of the psychological side of business and of the psychology of those with whom he deals. It strikes me that it is even more important, perhaps so much more important that it is universally realized and does not, therefore, require emphasis, that it is the inescapable responsibility of every engineer in every line of employment—except possibly in pure research, and there we apply the term engineer in a specialized sense—to understand the application and the possible market for the product on which he is working, and to regard it, not merely as an economic as well as a technical, but as an economic even more than a purely technical, problem.

While there is a great deal to be said on the psychological side, it seems to me there is something of a reciprocal responsibility. There are many men who conceive ideas of the greatest value and whose ideas ultimately are accepted through force of circumstance, but who, unfortunately for themselves and for others, are unable to develop the right psychology or the right personality to be able to sell. A very definite responsi-

[2] M.S.A.E.—Consulting engineer, Indianapolis.

[3] M.S.A.E.—Assistant research engineer, Studebaker Corp. of America, South Bend, Ind.

[4] M.S.A.E.—Assistant Secretary of the Navy for Aeronautics, Navy Department, City of Washington.

bility devolves on the business man to become also enough of an engineer to get the engineer's viewpoint, so that he will be capable of ferreting out the merit, where there is real merit, despite the inability of the proponent of the idea to put it effectively and dramatically before him.

One great advantage which the man of engineering training must have when he lays aside his technical pursuits and becomes primarily a business executive is the ability acquired from his previous training and experience to draw out and apprehend the merits of an idea that is incompletely exposed. That may be one reason why we see so many engineers, who had not only technical training but also those fortunate qualities of personality and psychology of which Mr. Shidle has hinted, in very high executive positions in the automotive industry and other industries, including some that are far removed from the normal pursuits of the engineer today.

Practical Psychology Applied

JOHN YOUNGER[5]:—Mr. Shidle's paper brings very forcefully before us a statement made recently by Alfred Sloan, president of the General Motors Corp., which should be weighed thoughtfully by engineers and, indeed, by all organization men. Briefly, he said that, in rating the value of a man, his ability to get on with other men—his personality, in fact—counted 75 per cent.

This recalls two incidents in my own work which made a deep impression and which are, I believe, pertinent to this discussion. The first occurred when I was in a minor position in a plant and did not like one of the executives. One day I unburdened myself of this dislike to one of the superintendents, who answered me by saying that, no matter in what plant I might find myself, there would always be some such person and that it was my job to "sell" myself to him. It is unwise to complain about him; we should try to see his good points and to sell ourselves to him on these points.

The other incident occurred when a friend told me that he could not get on with the president of the company and wanted to resign. My friend held an important position carrying prestige, and, feeling that he would be making a mistake, I told him that the easiest thing for a man to do is to resign but that a strong-willed man would realize the obstacles facing him and seek to overcome them. My friend took the advice, "sold" himself to his superior and "sold" the president to himself, to his ultimate great advantage.

What do these incidents and those given in Mr. Shidle's paper represent? Merely the application of practical psychology. If the engineer is to broaden himself in the business field, he cannot do better than to study and apply the principles of practical psychology.

Mr. Shidle did not mention the word "psychology"; probably, like myself, he feels there is much buncombe in what often passes for psychology, but his paper is a good example of practical psychology and its application.

One other point that I should like to mention is the importance, to engineers who wish to broaden themselves, of studying and applying the principles of economics. Far too many engineers are guided by purely engineering technical reasons. They do not realize the vast complexity of the organizations they are working for and they may make engineering changes that have a strong economic reaction on the whole business structure. A timely illustration may be taken from the balloon-tire situation. It was easy for the car engineer to specify the exact size of tire that suited his load and speed conditions, but the economic consequences reached all the way down to the small dealers in remote villages. I think, however, that engineers are coming more and more to an understanding of the economic consequences of their purely technical work; in fact, the successful engineer cannot disregard them. The engineer of tomorrow must be chosen not only for his technical ability; he must in addition be a business man with a keen eye for business reactions.

Successful Executive Is Not Dictatorial

H. M. CRANE[6]:—Mr. Younger mentioned the name of my present superior. I am in a business position of working for a man whom I like extremely well personally and whose professional ability I admire very highly. They do not always go together. Mr. Sloan graduated from the Massachusetts Institute of Technology in 1895. Gerard Swope, of the General Electric Co., graduated in the same class. Both, I think, disclaim the fact of being engineers. I have not talked with Mr. Swope for a long time, but I can say that Mr. Sloan is an engineer in the only sense that means very much, and that is based on the definition that engineering is nothing but trained common sense with a background of technical information.

The inferiority complex mentioned by Mr. Shidle comes very naturally from the fact that the engineer of old was a more or less menial person; he was a recorder of decisions by his superior. He first began putting down on paper what the boss decided to do in building a vessel, laying out the timbers and that sort of thing. Formerly, in England, an engineer was distinctly a man who worked with his hands.

The trouble with engineering is that it is supposed, from the outside, to deal with questions of fact. There is no doubt that we do work with facts; we work in feet and inches, and pounds of pressure, and such things which are, so far as our human intelligence goes, facts. On the other hand, there is no combination we put together and sell to the public that represents anything but compromise. If we do not make more than 45 per cent bad adjustments in the compromise and make 55 per cent good ones, we probably have a successful article.

That is the point where judgment enters. The chief engineer of a corporation cannot delegate that one thing. In the final adjustment of the compromise between different conflicting desirable and undesirable features that must be put together in an operating vehicle of any kind, the relations of the engineer with his superior really are the same as those of his men with himself.

Mr. Sloan's success in business rests on the fact that he is not an executive of the kind that has been much advertised in the past, I think especially in motion pictures, who pounds on the desk and orders this, that and the other man to do so and so. Of all the futile things in a big organization, that is the most futile. By the force of his own logic, Mr. Sloan is able to con-

[5] M.S.A.E.—President, editor, Automotive Abstracts Co., Columbus, Ohio.

[6] M.S.A.E.—Technical assistant to the president, General Motors Corp., New York City.

vince his subordinates of the right thing to do, and, when they are convinced through their own mental process, they do it. The reason is, I think, that no man in a responsible position can convey his own impression more than one stage down. He may order a man directly under him to do a thing a certain way and keep close enough watch to see that he does it, but, if he orders him to see that a third man does it that way, it probably will not be done right unless the intervening man believes fully with his superior that it is the right way to do it.

The "buck passing" during the war gave rise to some very clear and distinct rules. One is that the buck can always be passed downward, occasionally passed horizontally, but never upward.

W. T. FISHLEIGH[7]:—This paper has opened a question which for a number of years has been recognized as one of the most serious that confronts engineers at present. It is so serious that a number of institutions instructing young engineers have taken definite steps toward broadening the engineering courses. The general ingrowing trend begins with the young chap who is just entering college or even high school. He is instructed narrowly along mathematical or engineering lines, and before he is 20 years old he has come to have this inferiority complex which Mr. Shidle mentions, but which I think sometimes is a superiority complex, the feeling that he can prove that $2 \times 3 = 6$ and that, as an engineer, he is in an absolutely impregnable position. He does not realize that, with his personality and his way of presenting an idea, he could not prove to the ordinary public or the ordinary management that 2×3 equals anything.

EDUCATION ALONG BROAD LINES NEEDED

Some time ago I happened to be present at a discussion of the case of a chief engineer in charge of the work in a certain company when the question came up as to what could be done with that engineer. I raised the question if he was not particularly good technically and from a strictly engineering standpoint. There was no question about his training and his experience, or about his ability if he did not have to deal with other men. In spite of all this, the question was, what would have to be done with him. Even his removal from his position was considered, and one suggestion was made that the company would do better to engage an engineer who did not know one-tenth as much about technical engineering but knew a great deal more about salesmanship and general policies, and about human nature, team work and cooperation.

I have not been able for a long time to see why the engineer should not be trained and should not operate along broad general lines the same as the lawyer or the doctor. I believe thoroughly that, if the young man finishes school with the proper viewpoint and the proper training, he will progress in a broad usefulness as the lawyer or the doctor does.

The subject opened is an extremely interesting one and gives us all a chance to enquire, "Why cannot we engineers get on our feet and talk to sell a good idea as well as the average lawyer? By that I do not refer to great numbers of words but to a convincing friendly sort of presentation so that when we get through, if we have proposed that $2 \times 3 = 6$, the public and the management will agree with us.

NORMAN G. SHIDLE:—I agree most heartily with most of the remarks that have been made, and was particularly impressed with what Edward P. Warner said. Obviously, there is a counter-responsibility on the side of management, but I did not mention it because that gives the engineer a way out. If one were making a presentation of this subject to a group of general executives, I think that is the only side that might be well emphasized. Sometimes we need consciously to over-emphasize in our own minds. If we are to think straight, we must understand all the facts and their interrelation, but I think we should over-emphasize consciously once in a while.

ENGINEERING TOO HIGHLY SPECIALIZED

T. J. LITLE, JR.[8]:—From present indications it seems that the engineer's importance, at least in our industry, is gradually increasing; in other words, the engineer is coming into his own. I have noted in some cases slight jealousies in certain organizations arising from resentment against this trend, and references made at times to the impracticability of the average engineer as considered from a business viewpoint. This probably is accounted for by the fact that many engineers specialize highly in their particular lines and neglect the intimate contact with the different branches of their business, such as sales and purchasing, not caring to be bothered with such troublesome details.

This tendency probably is to be accounted for by the fact that, in many of our engineering colleges, engineering is so highly specialized that no attempt is made to give even the rudiments of a business education or to pay any attention to cultural training. Men so trained are, of course, handicapped from the start.

I believe that many engineers are technically fogbound, because they refuse to read or discuss anything except that pertaining directly to their own profession. This tends to produce an impractical genius. I think we would do well to broadcast practical advice along the foregoing lines in THE JOURNAL in the form of articles written by eminently successful business men and giving constructive advice for the engineer, by which I mean advice as to which books could be read most profitably and what civic and cultural activities should be followed by engineers.

It is a significant fact that we have had many cases in American history of engineers who have risen to great prominence in executive affairs and also developed into great statesmen. The first example is George Washington, who unquestionably qualified as a civil engineer of considerable ability, and in modern times we have Herbert Hoover, who is a great engineer as well as a statesman.

I see no reason why the activities of an engineer should be limited to his particular profession. We must expect to see the trained engineer occupying the chief executive positions in our industry, as many are already doing; for after all the engineer is a trained thinker and is admirably adapted to fill executive positions in a variety of occupations.

COMMON SENSE A NEEDED ATTITUDE

F. C. HORNER[9]:—This is a live subject and I want to compliment Mr. Shidle on the very interesting way in which he has dealt with it. He struck a keynote when

[7] M.S.A.E.—Engineer, Ford Motor Co., Detroit.
[8] M.S.A.E.—Chief engineer, Marmon Motor Car Co., Indianapolis.
[9] M.S.A.E.—Assistant to the vice-president, General Motors Corp., New York City.

he said that individual ability to think broadly in a business sense should be the engineer's aim.

After all, what is an engineer but a planner, an analytical director of ideas? He begins with a theory, originating in his imagination, which many ignorant people label "theoretical"; but, without someone having once been a theorist in *his* time, *we* should now have no practice to follow. The secret of the success of the engineers who have made real contributions to the advancement of civilization, in my opinion, is that, with all their theory, they have to a very large degree been possessed of more than the usual amount of common sense; and the classic definition of common sense is a *scientific use of the imagination.*

I cannot altogether agree with Mr. Shidle about most engineers having an inferiority complex. The majority of those I know are decidedly self-confident; in fact, in my opinion, one of the most deplorable faults of the engineer, particularly those in the automotive industry, is that they are over-confident of their own infallibility and hence seldom, if ever, are willing to lend an attentive ear to ideas that are not original with them. Neither do I agree that engineers are even relatively inarticulate. My experience has been that they are usually very loquacious in advancing their ideas or theories and truly Patrick Henry-like orators when defending something which they designed, with excellent intent no doubt, and frequently with truly brilliant imagination, but which will not stand the acid test of practical experience.

I heartily agree that splendid engineers often fail to make good with the management of their companies because they either cannot or will not try to see the management's, or what might be better termed the commonsense, side of the problem. As Mr. Shidle says, the engineer's ideas must fit into the business picture, which to me means that he can at least *listen* to the other man's arguments and be humble enough to study the requirements in the field and on the ground as well as in the laboratory and test room. That engineer, if other things are anywhere near equal, will make his mark and be a joy and inspiration to his associates and to those who use what he engineered into existence.

How Engineer's Status Has Changed

K. T. Keller[10]:—Engineering is the prime factor which has brought about lower production costs and greater efficiency in the automotive industry, and is largely responsible for the strong economic position the industry enjoys today. The mechanical design and the appearance of the motor-car have been developed greatly within the last few years, and have been identified by the types of powerplant used, which have been tested, proved and accepted by the public on their merits. The design of each of these has been standardized to a considerable extent within itself, and a number of features are practically standard in all types of powerplant.

Standardization has been brought about chiefly by the progressiveness of the industry in adopting proved designs and by public acceptance of the finished product. It has been a means of reducing the initial cost, thereby widening the market, which, in turn, has reduced the manufacturer's operating costs.

Standardization is but one of the factors that have resulted in not only lower costs, but consistent and stabilized costs as well. Present cost-finding methods, and the importance of accurate costs to the industry today, have been developed with the advance of the industry. Costs are now determined with considerable accuracy from designs before production is started.

The engineer of today has to be a business man if he is to be successful. By creating engineering standards he greatly reduces the enormous expenditures for machinery and equipment, new tools, and loss of time in getting into production, and thereby greatly reduces the loss of business.

The engineer should be interested in the cost of the product he designs; he should be particularly interested that the product shall be one that can be produced economically in quantities by machinery of standard designs. Thus, with cost considered from the very design of the product, losses from an underpriced product can be avoided and standards need not be lowered because of underpricing.

The great trouble with engineers of yesterday was that they regarded engineering as 100 per cent of the problem and cost as an after-consideration, whereas today cost is the first consideration and engineering follows, to design at a cost to the public that is so desired by the management.

In former years the automotive industry was dominated more or less by the sales departments; that is, the sales departments attempted to interpret the desires of the public and dictated what should be built. It is possible that this situation developed an inferiority complex in the average engineer, but today the engineer designs a product along standardized lines, in cooperation with the other divisions of the organization. In former years changes were often made in designs to supply good "sales talks," whereas now changes are the result of sound engineering, and the sales arguments are incidental. Hence, the status of the engineer has changed so that he is now on equal footing with the rest of the organization; he is frequently the leader, and his former inferiority complex has been replaced by assurance. The engineer is part of the operating organization and, as such, should enter into all manufacturing business problems where the design reduces or increases cost.

Engineering Division a Commercial Enterprise

K. L. Herrmann[11]:—It seems that business is a commercial enterprise and, therefore, the men conducting a commercial enterprise are "business men," and those working for the enterprise are "in business" in varying capacities. An engineering division of a motor-car manufacturing company is a commercial enterprise in which all the functions of a business are carried on. The products are drawings, specifications and models. The work necessary to produce these includes studies of styles, construction competition, drafting, pattern making, and foundry and machine-shop work. Also, there is the matter of personnel and the appropriation and expenditure of funds, very similar to that of any normal business.

The customers of the engineering department are the sales, manufacturing and direction divisions and, indirectly, as in the case of many other commodities, the public.

In any business, in addition to commercial matters, a special knowledge must be acquired. This is also true

[10] M.S.A.E.—Vice-president in charge of manufacturing, Chrysler Corp., Detroit.

[11] M.S.A.E.—Consulting engineer, Studebaker Corp. of America, South Bend, Ind.

of engineering. Every individual connected with an engineering department, before proceeding with any item of work, must consider the object of the work, the personnel equipment, and the funds and time available for conducting the test or producing the object. Unless these details are definitely set, there is no limit to the time, personnel and expense which can be applied to any of the thousands of items that can be investigated. In nearly all cases it is necessary to confine the research work to details which have a direct application to the early solution or completion of the product. I have in mind the testing of a very simple item, such as brake-lining, to which could justly be allotted 100 men provided with chemical laboratories and equipment, and there would constantly be sufficient work to keep them busy. On a similar basis, for all the items coming up, motor-car companies could have more men in engineering and research work than they have in production, because of the many arts and sciences involved in the designing and operation of motor-cars. Business judgment, therefore, must be exercised throughout the organization and in connection with special technical knowledge.

In engineering, as in business, incompetence, not including inexperience, and improper allotment of capital, equipment and personnel available, may be responsible for failures. Bradstreet reports that 5.2 per cent of all failures are due to inexperience, after an allowance of 70 odd per cent has been made for incompetence, lack of capital and the like. This may be an indication that special knowledge concerning the average of business is 5 per cent of the factors causing failure; and, in general, one might reason that technical knowledge accounts for a very small part in the success of an engineer, important as it may be.

In all business, judgment is never 100 per cent correct; the degree of success depends on the average result. Similarly, in engineering many mistakes may be made in appropriating funds, in personnel and in directing the work, either by the chief of the department or by any individual in charge of a minor division or project. It is the total result that determines progress and success.

Perhaps we all have an inferiority complex, and it is one of the items which keeps us from being 100 per cent perfect. Engineers have been improving as business men. Engineers of the earlier type eliminated themselves almost entirely and were succeeded by men of a much more normal business attitude, in which a knowledge of the technical side is but a fraction of the total qualification for the sucessful conduct of the enterprise.

Foundation on Which To Build Success

C. A. Musselman[12]:—Probably one of the most engaging thoughts expressed by Mr. Shidle is that which deals with the human side of the engineer's work. Possibly more changes affecting mankind have occurred in the last 25 years than in any other quarter of a century; and not the least of these has been the development of the idea that life is made up of give and take.

We no longer tolerate the man who sees but one side of a subject, and we contribute toward the success of those who we claim have balance. There was a time when a man in any profession was not supposed to have to fit into the grooves followed by the hard-headed, practical business man; but today we expect men, professional or otherwise, to be fairly well versed in the broad subjects of the hour and to avoid abnormal development of any one characteristic. Possibly we might say that the genius is giving way to the man of balance, and that common-sense, tolerance and general knowledge seem to be the foundations upon which most men build success.

Automotive engineering today does not consist entirely of evolving new principles and products or improving those which exist. Engineering in the highly competitive automotive market means designing something which will add to both the prestige and reliability of the product and incidentally prove to be something which is salable and cuts costs. Therefore, to be the most efficient engineer is positively necessary if the maximum of success is to be attained.

If these views are concurred in and if the thoughts which Mr. Shidle has started flowing seem to be leading to something definite and interesting, would it not be well that our discussions show us in detail how the engineer may become the most important factor in his organization?

Three Phases of Automotive Industry

O. E. Hunt[13]:—The subject of Mr. Shidle's paper is certainly a most pertinent one, even though it indicates a rather belated recognition on the part of the Society of a problem that has confronted engineers in our industry for some time past.

The position of the automotive engineer with relation to the business has, to my mind, gone through three major phases during the development of the industry in this Country. As Mr. Shidle points out, in the early days when the problem was largely one of making the car run at all, he occupied a dominating position. Later, when the public became convinced that cars would run and the demand for them increased at a higher rate than did the development of production facilities, his star was eclipsed by that of the production man. His position changed again when production expansion had become rather over-stimulated by war work, and, temporarily at least, the supply exceeded the demand.

At this third point the industry became highly competitive and the success of an individual organization depended upon its ability to convince the public that it gave a better result for a dollar than any other organization in its price class, if it wished to be an important factor in that price class. In such a market, technical, production and selling factors all have to be considered carefully so as to arrive at the best commercial compromise and stimulate the maximum public interest in the product. In other words, since the business depression immediately following the war, we have been in a competitive business that required an engineer, if he was to be broadly successful, to be about as good a business man as he was an engineer and as appreciative of the sales and production problems of his organization as he was of its technical problems.

This situation cannot be impressed too strongly upon the minds of our automotive engineers, since it affects both their own and the industry's future.

Business Sense Helps Engineer To Compromise

E. P. Blanchard[14]:—In some of the questions I have put up to the Production Committee in the chart for this

[12] A.S.A.E.—President and general manager, Chilton Class Journal Co., Philadelphia.
[13] M.S.A.E.—Chief engineer, Chevrolet Motor Co., Detroit.
[14] M.S.A.E.—Advertising and assistant sales manager, Bullard Machine Tool Co., Bridgeport, Conn.

year's production activities, an attempt was made to work the business point of view into production problems, as it relates to certain relationships between the quantity of raw stock on hand, the material in process and the volume of articles in production. These questions tend to indicate the business significance of certain factors with which the production man is dealing. This business aspect is concerned with equipment, too, in the way of material-handling equipment and production machinery.

I think there is too strong a tendency on the part of an engineer, whether he be a design or production engineer, to aim for an ideal set-up, or for what we may term "pure science", in which the last degree of refinement is not justified practically, from a consideration of cost or finance or market conditions. A fuller understanding of business will help the engineer to compromise, and, instead of "cramping his style", it will help him to make his style practical, to make his idea right from the business point of view.

Tact Essential to Business Success

H. W. ALDEN[15]:—I regard this paper as one of the best presentations of this subject I have ever read. The engineer has got to get it through his head that at least 90 per cent of his difficulties are of his own making. Incidentally, this does not apply to engineers only. One's natural inclination is to believe that his troubles arise from external causes. If the engineer can only shift his viewpoint so that he can see that most of his difficulties are of his own making, he will go a long way toward solving his troubles.

There are five essentials of business success, only one of which I shall mention; that is the element of tact. Years ago I used to place this element well down the line. The older I grow, however, the further up the line I place it. If we stood all the engineers up in a line and measured them with a rule for this element of tact, I wonder what would be the result.

A. J. SCAIFE[16]:—The Engineer as a Business Man is a very difficult subject to cover, but I believe Mr. Shidle has done a good job and brought his paper to a very definite conclusion, having in mind the one outstanding thought, that of authority.

Coupled with authority we must have ability; an ability not only to produce a mechanically successful design but a design that will meet with a favorable response from the buying public, whether it be a motorcar, a motor-truck or a motorcoach. We hear a great deal about "public demand". I have never felt that the public really *demands* anything, but the public responds to and accepts very readily that which is pleasing to the eye and fulfils the public's requirements from the service standpoint.

J. J. BALSOM[17]:—I believe Mr. Shidle's three points: first, selling one's ideas to the rest of the organization; second, that advancement depends, in part, on the general impression one makes on his organization; and third, "authority is never delegated, authority is *earned*", are applicable not only to engineering but to any other division of industry, be it selling, production, finance or engineering.

CARL BREER[18]:—I think Mr. Shidle has struck a chord that is important to every engineer. The average engineer is so conscientious that, in most cases, he lacks salesmanship to put his ideas across. The result is that he is buffeted about and unsold on his decision for fear of a solution not being 100 per cent correct. There is a marked distinction between a theoretical ideal of meeting a situation 100 per cent and that of a commercial ideal that may call for only a 95-per cent answer.

Mr. Shidle has put into this paper a lot of food for thought for the average engineer in the automotive industry.

[15] M.S.A.E.—Chairman, board of directors, Timken-Detroit Axle Co., Detroit.

[16] M.S.A.E.—Chief field service engineer, The White Co., Cleveland.

[17] M.S.A.E.—Auditor, Harley-Davidson Motor Co., Milwaukee.

[18] M.S.A.E.—Executive engineer, Chrysler Corp., Detroit.

Can an Adult Learn?

SOME recent studies of the capacity of grown-ups to acquire fresh skill throw new light on this question. One of the most interesting investigations is that of Prof. E. L. Thorndike, of Teachers College, Columbia University. During the last 2 years he has conducted experiments with two groups, one averaging in age 42, the other 22, years. Both were compared with a group of children.

The adults were taught to write with the wrong hand, to operate the typewriter, and there were classes in algebra, science, foreign languages, and the like. For all three groups there were classes in reading, spelling, arithmetic and other elementary-school subjects. In general, both adult groups learned more rapidly than the group of children. The group of older adults learned almost as rapidly as the younger adult group—roughly, about five-sixths as fast.

The conclusion is that ability to learn increases until about 20, when it remains stationary for a time, provided the adult continues to study, and then declines very gradually. No one under 50 should be deterred from trying to learn something new by the fear of being too old, if he has developed the study habit. The studies show that even after 50 the decline is so slow that the attempt to learn is still well worthwhile.

Lack of opportunity or desire to learn now appears to be the explanation of why adults so seldom learn a new language or a new trade. But opportunity and desire have greatly increased everywhere in this Country recently.

The Public Library of Newark reports that about 10,000 young people in that city—mostly men between 20 and 32 years of age—pay yearly more than $200,000 to correspondence schools. These young men have had little formal education and are mostly working at trades not requiring great skill.

The companies that have furnished training opportunities to their employes are satisfied that capacity to learn is not always and singly a question of age.—Executives Service Bulletin, Metropolitan Life Insurance Co.

Dew-Point Data on Gasoline[1]

By Oscar C. Bridgeman[2]

SEMI-ANNUAL MEETING PAPER — *Illustrated with* CHARTS AND DRAWINGS

PREVIOUS reports to the Society on the fuel-volatility work being conducted at the Bureau of Standards in cooperation with the automotive and the petroleum industries included a description of an apparatus and method for the determination of volatility, and a correlation over the range from 10 per cent to 90 per cent was pointed out between data obtained by this method and the distillation curves of the fuels as determined by the procedure practised by the American Society for Testing Materials. The present paper covers an extension of the range to 100 per cent evaporated, which constitutes the dew-point line.

With the Sligh equilibrium air-distillation apparatus, dew-point data for 21 diverse gasolines were obtained. These covered mixtures of air and fuel from 8-1 to 20-1, by extrapolation of the equilibrium air-distillation curves to 100 per cent evaporated. For each mixture, the dew-point temperatures were found to be related to the 90 per cent A.S.T.M. distillation points of the fuels by a simple ratio of absolute temperatures independent of the particular gasoline employed. Similar results for mixtures from 1-1 to 16-1 were obtained with a modified Stevenson and Babor apparatus on five gasolines, using an illuminated platinum black surface to detect condensation of liquid. With the latter apparatus, values of the normal dew-point at a pressure of one atmosphere in the absence of air were obtained for 15 gasolines, and these were found to be related to the 90 per cent A.S.T.M. point by a simple ratio of the absolute temperatures. Corroborative evidence was obtained from measurements of the equilibrium-solution temperatures of five gasolines. The temperature ratios obtained by these two methods were in good agreement with one another and with ratios computed from the work of seven other sets of observers by four different methods.

An equation was obtained for the ratios between the absolute temperatures of the normal dew-points and the dew-points of the various air-fuel mixtures in terms of mixture ratio as the independent variable, and values computed from this equation were in good agreement with the work of other investigators. Molecular-weight determinations were made on 24 gasolines and an approximate relation to density was deduced. Using the molecular-weight values, the temperature ratios were expressed analytically in terms of partial pressures of the fuel in the mixtures. By means of equations deduced from the experimental data, it is shown that the dew-point of a mixture at any reduced pressure can be evaluated. The general conclusion reached is that the dew-point for any mixture of commercial gasolines and air can be computed accurately from the 90 per cent A.S.T.M. distillation point without having recourse to any additional experimentation.

IN recent reports to the Society on that phase of the Cooperative Fuel Research work dealing with fuel volatility, there have been presented a description[3] of an apparatus and method for the determination of gasoline volatility, a correlation[4] between volatility data by this method and the distillation curves of the fuels as determined for the procedure practised by the American Society for Testing Materials, and the relation[5] between these volatility data and ease of engine starting.

In the correlation of the A.S.T.M. and equilibrium air-distillation curves it was shown in a preliminary manner, on the basis of 15 gasolines, that at any common percentage evaporated between 10 per cent and 90 per cent the absolute temperature on the A.S.T.M. distillation curve, corrected for loss, divided by the absolute temperature on an equilibrium air-distillation curve, is a constant independent of the particular gasoline used. Different temperature-ratios were obtained for every percentage evaporated and for every resultant mixture formed in the equilibrium air-distillation, and formulas were given showing the variation of temperature ratio with the percentage evaporated and with the mixture. Since the last report, data on 10 additional samples have been obtained, and the results on these new gasolines verify the conclusions reached on the basis of the preliminary work. Complete data on the temperature ratios for these 25 diverse gasolines from 10 per cent to 90 per cent evaporated are given in Appendix 2, together with a description of the samples and the specification data.

Whereas these data appeared to cover adequately all mixtures of interest in connection with automotive engines, namely, resultant air-vapor mixtures from 8-1 to 20-1, they were deficient in two respects. The temperature of 100 per cent equilibrium vaporization in the presence of air is of considerable interest in connection with normal engine-operation and, while the Sligh apparatus seemed capable of giving these dew-points accurately, it appeared advisable to make measurements also on identical samples with some of the other types of apparatus which have been proposed. The methods used and the dew-point results obtained constitute the material given in this report.

The other deficiency was at small percentages evaporated. Since the Sligh equilibrium air-distillation apparatus was used only with a water bath, it was not always possible to determine the temperature of 5 per cent evaporated or less; hence the correlation with the A.S.T.M. distillation curve over this range is less certain than the correlation over the range of higher percentages evaporated. The equilibrium air-distilla-

[1] Published by permission of the Director of the Bureau of Standards, City of Washington.

[2] Research associate, Bureau of Standards, City of Washington.

[3] See THE JOURNAL, April, 1926, p. 393, and August, 1926, p. 151.

[4] See THE JOURNAL, April, 1928, p. 437.

[5] See THE JOURNAL, March, 1927, p. 353.

tion temperatures at small percentages evaporated are important from the standpoint of engine starting in very cold weather and, accordingly, additional information in this range was desirable. Since the results obtained with the Sligh apparatus are considerably less accurate at very small percentages evaporated than at the higher percentages, measurement of vapor pressures and molecular weights of the vapors seemed to be a more feasible method of obtaining the desired temperatures. Work is in progress on this latter phase of the problem.

Previous Work

The previous work on dew-points of gasoline can be divided into two general classes, depending upon whether they were determined in the presence or absence of air. Measurements in terms of temperatures corresponding to various air-fuel mixtures will be considered first.

Gruse[6] passed various mixtures of air and fuel, from about 10-1 to 18-1, through a preheating coil and measured both the appearance and disappearance of dew on a metallic mirror cooled internally. Sligh[7], using the equilibrium air-distillation apparatus designed by him, obtained dew-point values on five fuels for mixture ratios from 4-1 to 15-1. Brown[8], with a slightly modified Sligh apparatus, secured data on a considerable number of gasolines for a 12-1 mixture. Stevenson and Babor[9], employing a dynamic method and using a plattinum black surface to indicate condensation, obtained the dew-points of seven gasolines for mixtures from 1-1 to 30-1. Preliminary results on eight gasolines for mixture ratios from 4-1 to 20-1 were reported by the Bureau of Standards[10] at the 1928 Annual Meeting. All these data were obtained at a total pressure of one atmosphere.

Dew-point measurements on gasoline vapor in the absence of air, at both atmospheric and reduced pressures, have been made by a number of investigators. Wilson and Barnard[11] did the pioneer work on this phase of gasoline volatility by measuring the temperatures at which equilibrium solutions were formed at a pressure of one atmosphere. This method was later adopted by Whatmough[12] and by Ormandy and Craven[13] for use with British fuels. James[14] and, later, Brown[15], determined the amount of gasoline vaporized under conditions approaching equilibrium, by passage through a heated tube and spiral respectively at a pressure of one atmosphere, and these curves, extrapolated to 100 per cent, give the normal dew-points. Stevenson and Stark[16] published one curve over the range from 0 per cent to 100 per cent evaporated, giving similar results obtained with a static system. These latter investigators obtained data on six gasolines by a phase-change method, making a slight correction to atmospheric pressure; but this method was superseded by the one published by Stevenson and Babor[17], in which a platinum black surface was used to detect condensation. At pressures below atmospheric, Kennedy[18] made some measurements by a static method, as also did Wilson and Barnard[19] with equilibrium solutions.

Theoretical Discussion

The dew-point of a mixture is the temperature at which the vapor is in equilibrium with an infinitesimal amount of the liquid phase at a given total pressure. It can be approached from either side, by determining the temperature at which the last traces of liquid disappear or at which the first traces of liquid appear; and, in fact, it is theoretically necessary for the proof of the existence of equilibrium conditions that both methods be used and that both give identical results within the experimental error. Hence, when temperature is plotted against percentage evaporated, the dew-point line is the line of 100 per cent evaporated, and for each gasoline the temperature at any point on this line is uniquely defined by the pressure of the fuel vapor, or by its equivalent, the mixture ratio at a given total pressure. All experimental data recorded in this report were obtained at a total pressure of one atmosphere. Since it is obviously impossible to determine when only an infinitesimal amount of liquid remains, the logical procedure is to make measurements at various percentages evaporated and extrapolate to 100 per cent. Also, since it is impossible to make analogous measurements with dry superheated vapor and extrapolate to 0 per cent condensed, it is desirable, in carrying out dew-point measurements by approaching saturation from the dry condition, to vary all possible factors which might influence the results and to calibrate the apparatus very carefully. Determinations of the dew-points were effected from the liquid side by means of the Sligh equilibrium air-distillation apparatus, while by approach from the dry state, they were measured by means of an apparatus similar to that employed by Stevenson and Babor.

The dew-point of any material in the absence of air at a pressure of one standard atmosphere can well be called the normal dew-point, since it is just as definite a characteristic of the material as is the normal boiling-point. These two points are identical in the case of a material containing only one component. Theoretically the normal dew-point of a gasoline is identical with (*a*) Wilson and Barnard's atmospheric Equilibrium Solution Temperature; (*b*) Stevenson and Stark's Deppé End-Point; (*c*) Stevenson and Babor's Equilibrium End-Point; and (*d*) Whatmough's Equilibrium Boiling-Point. The term normal dew-point (NDP) has been adopted and used throughout this report.

In addition to the measurements made with the two types of apparatus already mentioned, measurements were made of the equilibrium-solution temperatures of several gasolines for the purpose of comparison. These

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[6] See *Industrial and Engineering Chemistry*, vol. 15, p. 796; *Oil and Gas Journal*, vol. 22, p. 86; *Petroleum Age*, vol. 12, p. 20; *Chemical and Metallurgical Engineering*, vol. 29, p. 970, and vol. 30, p. 364.

[7] See The Journal, August, 1926, p. 151.

[8] See The Journal, September, 1927, p. 280; University of Michigan Engineering Research Bulletin No. 7, 1927; *Bulletin of the American Petroleum Institute*, Jan. 31, 1927, p. 160.

[9] See *Industrial and Engineering Chemistry*, vol. 19, p. 1361.

[10] See The Journal, April, 1928, p. 437.

[11] See *Industrial and Engineering Chemistry*, vol. 13, p. 906, and vol. 17, p. 428; The Journal, March, 1923, p. 287.

[12] See *Industrial and Engineering Chemistry*, vol. 18, pp. 43 and 609; *Proceedings of the Institution of Automobile Engineers*, vol. 17, p. 346, and *The Automobile Engineer*, vol. 17, pp. 15, 452 and 484.

[13] See *Journal of the Institute of Petroleum Technologists*, vol. 9, p. 368.

[14] See The Journal, May, 1926, p. 501.

[15] See The Journal, September, 1927, p. 280; University of Michigan Engineering Research Bulletin No. 7, 1927; *Bulletin of the American Petroleum Institute*, Jan. 31, 1927, p. 160.

[16] See *Industrial and Engineering Chemistry*, vol. 17, p. 679.

[17] See *Industrial and Engineering Chemistry*, vol. 19, p. 1361.

[18] See Bureau of Standards Scientific Paper No. 500.

[19] See *Industrial and Engineering Chemistry*, vol. 13, p. 906, and vol. 17, p. 428; The Journal, March, 1923, p. 287.

methods and the results obtained are treated herewith in turn.

Dew-Point Values with the Sligh Apparatus

The Sligh equilibrium air-distillation apparatus has been previously described in detail[20]; so, no further description here is needed. It might be pointed out again that the apparatus had been calibrated by the use of various rates of feed at different temperatures, and that the observed results were always corrected to equilibrium values by means of a small correction factor. Measurements with pure toluene indicated that the results thus corrected closely approximated true equilibrium values.

The type of curve obtained with the Sligh apparatus is shown in Fig. 1 for U. S. Motor gasoline. The continuous lines represent supplied air-fuel mixtures of 4-1, 8-1, 12-1 and 16-1, and indicate the temperatures at which various percentages are evaporated from these mixtures. The dotted lines show the resultant air-vapor mixtures of 12-1, 16-1 and 20-1 formed from the supplied mixtures. The dew-points of these mixtures are obtained by a slight extrapolation to the line of 100 per cent evaporated. This intercept is rendered more certain by the fact that the supplied and the resultant-mixture lines must intersect at this point, which essentially amounts to a double smoothing of the data, thus increasing the accuracy with which the dew-point temperatures can be obtained.

The results on 21 gasolines for mixture ratios of 8-1, 12-1, 16-1 and 20-1 have been obtained by extrapolation of the air-vapor and air-liquid gasoline-curves in the manner just described. The description of these gasolines and their specification data are given in Appendix 2. Since it is impossible to obtain the temperature of 100 per cent evaporated on the A.S.T.M. distillation curve, due to the residue remaining in the distillation flask, the dew-point temperatures of these gasolines were compared with the 90 per cent A.S.T.M. points, corrected for distillation loss. For each gasoline, the absolute temperature of this latter point was divided by the absolute temperature of the dew-points of the various mixtures mentioned, and these temperature ratios are shown in Table 1 together with the 90 per cent A. S. T. M. temperatures of these gasolines. The ratios for each mixture are fairly constant, the average deviation being 0.007, or 0.5 per cent, and they appear to be independent of the particular gasoline used.

[20] See The Journal, April, 1926, p. 393, and August, 1926, p. 151, and April, 1928, p. 437.

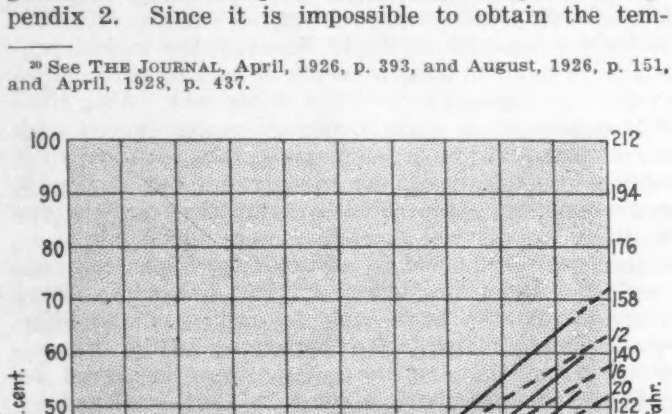

Fig. 1—Equilibrium Air-Distillation Curves Obtained for U. S. Motor Gasoline with the Sligh Apparatus

TABLE 1—RATIO IN ABSOLUTE DEGREES OF THE 90 PER CENT A.S.T.M. AND DEW-POINT TEMPERATURES FOR VARIOUS AIR-FUEL MIXTURES, THE DATA BEING OBTAINED WITH THE SLIGH EQUILIBRIUM AIR-DISTILLATION APPARATUS

Fuel	90 Per Cent A.S.T.M. Distillation Point, Deg. Cent.	Deg. Fahr.	Temperature Ratios Mixtures 8–1	12–1	16–1	20–1
1	199	390	1.37	1.39	1.41	1.43
3	197	387	1.37	1.40	1.42	1.45
A	196	385	1.38	1.41	1.42	1.44
B	132	270	1.35	1.38	1.43	1.48
C	174	345	1.37	1.39	1.42	1.45
D	200	392	1.37	1.40	1.42	1.45
E	199	390	1.39	1.41	1.43	1.45
F	198	388	...	1.40	1.42	1.44
RH	168	334	1.37	1.40	1.42	1.44
L	152	306	...	1.40	1.42	1.43
RPC	198	388	1.37	1.39	1.42	1.45
2	195	383	1.38	1.41	1.43	1.46
6	190	374	1.37	1.40	1.43	1.45
G	178	352	1.39	1.41	1.44	1.46
H	186	367	1.37	1.39	1.41	1.44
I	177	351	1.38	1.40	1.42	1.45
J	207	405	1.39	1.41	1.43	1.45
K	176	349	1.37	1.40	1.41	1.43
M	222	432	1.37	1.40	1.42	1.44
N	204	399	1.38	1.40	1.42	1.44
O	200	392	1.38	1.40	1.42	1.44
Average			1.375	1.400	1.422	1.446
Average △			0.008	0.005	0.006	0.009

Normal Dew-Point Measurements with a Stevenson and Babor Apparatus

To determine the normal dew-point by approaching it from the superheated-vapor phase, a modified Stevenson and Babor apparatus was constructed. The original apparatus used by these investigators was heated by superheated steam while, in the modified apparatus, electrical heating was employed as shown in Fig. 2. A pyrex glass tube 20 in. long and of ¾-in. inside-diameter was covered for a distance of 12 in. with a thin sheet of asbestos paper around which was wound resistance wire. The whole heating element was then coated with alundum cement. This tube was placed inside another pyrex glass tube 15 in. long and of 1⅝-in. inside-diameter and was centered by means of three tight-fitting asbestos-board washers, ¼ in. thick, as shown. The space between the upper and the middle washers around the heating element was filled with magnesia, while the space between the middle and lower ones was not filled to permit inspection of the platinum black surface. The outer pyrex tube was lagged over its entire length with a piece of cork-pipe insulation and was provided at the bottom with two slits at an angle of about 90 deg. around the circumference, one

TABLE 2—CHECK DETERMINATIONS OF NORMAL DEW-POINT TEMPERATURES WITH MODIFIED STEVENSON AND BABOR APPARATUS

	Good Series Fuel *J*, Mv.	Average Series Fuel *C*, Mv.	Poor Series Fuel *M*, Mv.
	8.89	7.45	10.05
	8.87	7.45	10.00
	8.84	7.40	10.14
	8.87	7.48	10.07
	8.87	7.37	10.22
	8.86	7.44	10.25
	8.87	...	10.00
	...	...	10.07
Average	8.87	7.43	10.10
Average △	0.009	0.032	0.078
Corresponding Temperature Deviations[21]			
Deg. cent.	0.2	0.6	1.5
Deg. fahr.	0.4	1.1	2.7

[21] Note that 1 deg. cent. = 0.0526 mv., approximately.

being used for projecting a beam of light on the platinum black cone and the other for observing the condensation of liquid on this surface. Just below the bottom of the outer tube, a side tube was sealed into the inner pyrex tube for the removal of the vapor passing through the apparatus. To assist in the vaporization of the gasoline, a rod was suspended in the upper part of the inner tube to which were soldered several rings of fine-mesh wire-gauze. The platinum black cone was inserted from the bottom of the tube and was provided with a thermocouple soldered to the cone and a tube for an airstream to cool the cone internally. This cone was a part of a complete dew-point apparatus very kindly given to the Bureau by Professor Stevenson and is described in detail in the article by Stevenson and Babor[22]. The thermocouple was calibrated and was used in conjunction with a sensitive millivoltmeter.

Obviously, the point at which the first infinitesimal trace of liquid separates cannot be detected by this method, and supercooling of the portion under observation always occurs. On the other hand, due to temperature gradients, the thermocouple may not indicate the true temperature of the portion of the cone under observation. Further, although the band of light flashes up very rapidly with rich mixtures, the time factor becomes important with lean mixtures, and it is necessary to decide on the intensity of light to be taken as a criterion of the dew-point. Care in the selection of the point on the cone to which the thermocouple is soldered so as to counterbalance the supercooling, and use of pure substances or mixtures with known dew-points as a means of choosing the proper criterion, permit an accurate determination of the dew-points of gasoline vapors and of air-gasoline mixtures, particularly in view of the fact that the change in temperature with amount condensed is not very large near the dew-point. The platinum black cone used in this work was tested by dew-point determinations with pure toluene and chlorobenzene, and the observed values were within 0.5 deg. cent. (0.9 deg. fahr.) of the normal boiling-points.

The first series of measurements made with this apparatus was on the normal dew-points of 15 gasolines. In performing these experiments, a burette containing gasoline was inserted into the small inlet-tube at the top of the apparatus by means of a rubber tube, and the gasoline was allowed to drip onto the wire screens at the rate of about 2 to 3 drops per sec. A drain pipe, not shown, was inserted in the lower stopper to permit removal of any liquid which condensed in the lower part of the apparatus. The current passing through the heating coil was adjusted until the platinum black surface changed in appearance from shiny to dull black, thus indicating complete vaporization. The temperature of the vapor was raised about 20 to 30 deg. cent. (36 to 54 deg. fahr.) above this point, and internal cooling of the platinum black tip was effected by slowly turning on the air supply. A series of readings was made of the temperature at which a shiny band of light just appeared and, in between each reading, the temperature of the tip was allowed to rise about 10 deg. cent. (18 deg. fahr.) by decreasing the air supply. Three sample series of readings are shown in Table 2, representing good, average and poor checks. Since the dew-point temperatures determined with the Sligh apparatus were found to be related to the 90 per cent A.S.T.M. points, it seemed reasonable that the normal dew-points were likewise related.

[22] See *Industrial and Engineering Chemistry*, vol. 19, p. 1361.

Table 3 shows the normal dew-point temperatures for 15 gasolines, the 90 per cent A.S.T.M. points of these gasolines, and the ratios of the two temperatures in absolute degrees for each gasoline. These ratios are very constant and it appears that the normal dew-point of any gasoline commercially available at present can be obtained directly from the A.S.T.M. curve corrected for loss, without recourse to additional experimentation.

Dew-Point Measurements on Air-Gasoline Mixtures

In using the modified Stevenson and Babor dew-point apparatus for mixtures of air and gasoline, definite mixtures obtained by means of the Sligh apparatus were employed. The air-vapor exhaust-pipe of the equilibrium air-distillation apparatus was closed near the separating chamber, and the drain pipe, which ordinarily was connected to the burette for measurement of the liquid residue, was connected instead to the tube in the upper part of the dew-point apparatus. It was found that better results could be obtained by adjusting the temperatures in the Sligh vaporization coil and the dew-point apparatus, so that partial evaporation only took place in the former apparatus and vaporization was completed in the latter. The rest of

TABLE 3—RELATION BETWEEN THE ABSOLUTE 90 PER CENT A.S.T.M. AND NORMAL DEW-POINT TEMPERATURES OF GASOLINE VAPOR AT A PRESSURE OF 760 MM.

Fuel	Normal Dew-Point, Deg. Cent.	Normal Dew-Point, Deg. Fahr.	90 Per Cent A.S.T.M., Deg. Cent.	90 Per Cent A.S.T.M., Deg. Fahr.	Ratio
A	156.6	313.9	196	385	1.091
B	101.2	214.2	132	270	1.082
C	138.4	281.1	174	345	1.086
D	162.5	324.5	200	392	1.086
E	161.7	323.1	199	390	1.086
F	160.0	320.0	198	388	1.087
H	151.0	303.8	186	367	1.083
I	143.0	289.4	178	352	1.085
J	164.8	328.6	204	399	1.089
K	143.0	289.4	177	351	1.081
L	120.2	248.4	152	306	1.080
M	186.8	368.2	222	432	1.078
RH	133.4	272.1	168	334	1.084
RL	113.2	235.8	147	297	1.087
RPC	162.2	324.0	198	388	1.082
				Average	1.084 ± 0.003

the procedure was the same as that outlined in connection with the normal dew-point measurements, the main difference being that, as leaner mixtures were used, it became increasingly difficult to estimate the initial deposition of dew on the platinum black surface and, accordingly, there was more variation between the individual results of any one series.

Data on five gasolines were obtained for mixtures of 1-1, 2-1, 4-1, 8-1 and 16-1. These values are given in Table 4 expressed as ratios of the normal dew-point temperatures to the dew-point temperatures of these various mixtures, both in absolute degrees. Transformation from normal dew-points to 90 per cent. A.S.T.M. points can be effected by multiplying the temperature ratios by 1.084, since $T_{90\ per\ cent} = 1.084\ T_{NDP}$. See Table 3.

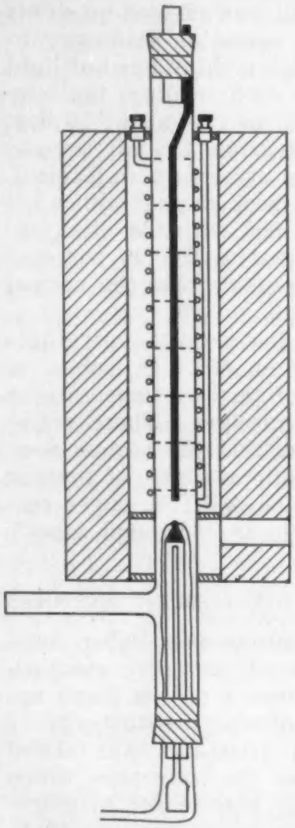

FIG. 2—MODIFIED STEVENSON AND BABOR APPARATUS FOR DETERMINING THE NORMAL DEW-POINT BY APPROACH FROM THE SUPERHEATED-VAPOR PHASE

Considerable interest has been shown in this Country and in England in the determination of the equilibrium-solution temperatures of gasolines and, accordingly, a few measurements of this point were made with five gasolines. After trying several designs of apparatus, the one shown in Fig. 3 appeared to be the most satisfactory and had the advantage of requiring a small amount of gasoline. The inverted flask sticking into the right arm of the U-shaped vessel contained the main gasoline supply and was used to maintain a constant liquid level in the U. The neck of the inverted flask had an inside diameter of 3/8 in. and the arms of the U had an inside diameter of 7/8 in. With these dimensions, the liquid level remained constant to about ±1 mm. It is realized that small amounts of the lighter fractions were lost in the air above the liquid in the inverted flask, but this should not introduce any very great error, and it did not seem worthwhile to design a complicated apparatus for purposes of obtaining a few results on equilibrium-solution temperatures in view of the disadvantages which the method possesses. The tube connecting the two arms of the U was purposely made small, about 3/16 in. inside diameter, so as to avoid heating of the liquid in the right arm, thereby losing a considerable part of the lighter fractions. The gasoline vaporized was condensed in the condenser at the left and drained into a flask.

To minimize superheating of the liquid, which is one of the chief disadvantages of this method, boiling tubes were inserted in the left arm of the U and rested on the bottom. These tubes were simply thin glass capillaries about 3 in. long sealed off in the middle,

TABLE 4—RATIO OF NORMAL DEW-POINT TEMPERATURE IN DEGREES ABSOLUTE TO DEW-POINT TEMPERATURES IN DEGREES ABSOLUTE OF VARIOUS AIR-GASOLINE MIXTURES

Fuel	Mixtures 1–1	2–1	4–1	8–1	16–1	Normal Dew-Point, Deg. Cent.	Deg. Fahr.
B	1.110	1.154	1.202	1.247	....	101.2	214.2
C	1.115	1.159	1.205	1.247	1.305	138.4	281.1
A	1.120	1.160	1.210	1.261	1.300	156.6	313.9
J	1.112	1.150	1.203	1.241	1.290	164.8	328.6
M	1.109	1.162	1.214	1.253	1.310	186.8	368.2
Average	1.113	1.157	1.207	1.250	1.301	....	....
Average △	0.003	0.004	0.004	0.006	0.006	....	....

constituting an inverted vapor space. On heating, vaporization of the gasoline into this space occurred, thus forming a two-phase system and effectively preventing undue superheating in this region of the vessel. The boiling tubes resulted in the evolution of a vigorous stream of gas bubbles from the bottom which served very efficiently to stir the whole liquid mass. With these precautions, it is felt that superheating, which commonly amounts to 10 deg. cent. (18 deg. fahr.) or more, was largely eliminated. Two calibrated thermometers were used, one in the liquid and the other in the vapor. Gasoline was allowed to flow through the apparatus until the readings of the thermometers remained essentially constant for at least 15 min. The time required for a measurement was about 3 hr. and, during this time, the original 25 ml. (1 ml. = 1 milliliter = 1.000027 cc.) of gasoline in the left arm of the U-tube was replaced four or five times. Constancy of temperature was taken as the sole criterion of the attainment of equilibrium, and no analysis was made of the condensate to establish its identity with the original gasoline.

The results obtained with the equilibrium-solution apparatus are shown in Table 5. The reading of the thermometer in the liquid was always higher than that in the vapor, the average difference being 13 deg. cent. (23.4 deg. fahr.). Unquestionably, the indicated liquid temperature was higher than the true equilibrium-solution temperature due to some superheating and to absorption of radiant energy from the heating flame. On the other hand, the indicated vapor temperature was too low, due to radiation loss and to the effect of the

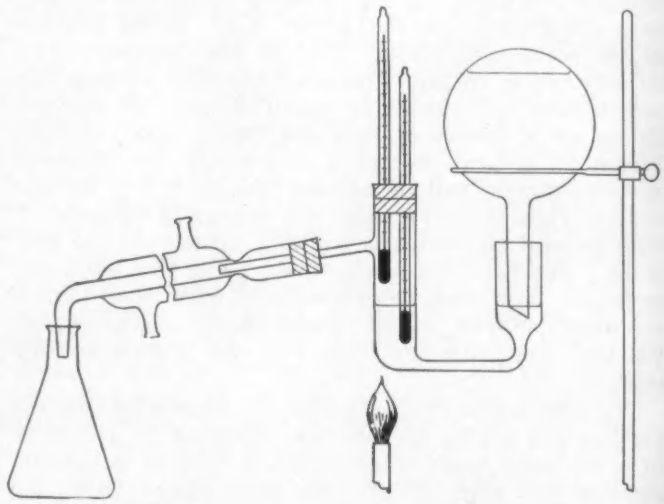

FIG. 3—APPARATUS FOR THE DETERMINATION OF THE EQUILIBRIUM-SOLUTION TEMPERATURES OF GASOLINES

condensed liquid running down the thermometer stem. The best approximation to the true equilibrium-solution temperature seemed to be the mean of the two thermometer readings. These mean temperatures are seen to be very close to the normal dew-point values for the same gasolines obtained with the modified Stevenson and Babor apparatus, the average difference being about 1 deg. cent. (1.8 deg. fahr.), which is probably fortuitous. The ratio of the temperatures in degrees absolute of the 90 per cent A.S.T.M. points and the equilibrium-solution points, 1.089, is in good agreement with the value of 1.084 obtained from the normal dew-point data given in Table 4.

Comparison with Data of Other Investigators

All the available data in the literature on normal dew-points were investigated, and where these values were given in conjunction with the distillation curves of the fuels, whether numerically or graphically, temperature ratios were computed using the 90 per cent A.S.T.M. points. In cases where no mention was made of correction of the distillation curves for loss, and where it seemed obvious that this had not been done, a correction of — 4 deg. cent. (— 7.2 deg. fahr.) was applied. This value was the average of results on about 20 samples of commercial gasolines. A summary of the average values from these computed data obtained from the published work of other observers is given in Table 6, together with the method employed and the number of gasolines tested, and a comparison is made with the average values obtained in the present work.

The agreement of the Bureau of Standards results by two methods with those of Stevenson and collaborators by three methods is very good. The agreement with the average value obtained from the data of James and of Whatmough is also good, although the deviations are considerably larger in these latter cases, while the average ratio computed from the work of Brown is considerably higher. Ratios from the data of Wilson and Barnard and of Ormandy and Craven are somewhat lower. It is to be noted that the average of the values given for the last three sets of investigators does not differ appreciably from 1.08.

It was suggested by Wilson and Barnard that the equilibrium-solution temperature was approximately equal to the 85 per cent A.S.T.M. temperature, although later work published by them on 14 gasolines and kerosenes indicated that the latter temperatures were consistently higher by an average value of 11 deg. cent. (19.8 deg. fahr.). The average error introduced by assuming the equivalence between the 85 per cent A.S.T.M. point and the normal dew-point, considered identical with the equilibrium-solution temperature, is 24 deg. cent. (43.2 deg. fahr.) for the 15 gasolines used in the present work. The lack of agreement with this 85 per cent rule is in accord with the work of Whatmough who concluded that, for British fuels, the equilibrium-solution temperatures were equal to points on the A.S.T.M. curves considerably lower than the 85 per cent temperatures.

A comparison of the Bureau of Standards results on the dew-points of various air-fuel mixtures with those computed from the published work of other observers is shown in Table 7, in the form of temperature ratios referred to the normal dew-point temperatures. The temperature ratios are the average values obtained from the individual results on the number of gasolines recorded in each case in the last column. When the normal dew-point temperatures were not given, these were calculated from the 90-per cent points by division of the absolute temperature of the latter by the factor 1.084. A correction of — 4 deg. cent. (— 7.2 deg. fahr.) was applied to the 90-per cent points in cases where loss has not been included in the distillation data.

TABLE 6—COMPARISON WITH RATIOS BETWEEN 90 PER CENT A.S.T.M. TEMPERATURES AND NORMAL DEW-POINT TEMPERATURES COMPUTED FROM DATA PUBLISHED BY OTHER OBSERVERS

Observer	Method	Ratio	Samples
Bureau of Standards	Dew-Point Apparatus	1.084 ± 0.003	15
Bureau of Standards	Equilibrium Solution	1.089 ± 0.003	5
Stevenson and Babor	Dew-Point Apparatus	1.084 ± 0.007	7
Stevenson and Stark	Phase-Change	1.080 ± 0.006	6
Stevenson and Stark	Equilibrium Distillation	1.077	1
James	Equilibrium Distillation	1.08 ± 0.02	12
Whatmough	Equilibrium Solution	1.085 ± 0.018	37
Brown	Equilibrium Distillation	1.13 ± 0.02	5
Wilson and Barnard	Equilibrium Solution	1.05 ± 0.01	14
Ormandy and Craven	Equilibrium Solution	1.07 ± 0.003	3

Good agreement is shown between the Bureau of Standards data by two methods and the data of Stevenson and Babor over the whole range of mixture ratios. There is also good agreement between these ratios for a 12-1 mixture and that computed from the values of Brown. Results calculated from the work of Gruse and of Kennedy are consistently lower, while those from the work of Wilson and Barnard are consistently higher. The average differences in dew-point temperatures between the observed values and those computed from the ratios obtained in the present work are respectively: 9 deg. cent. (16.2 deg. fahr.) for Gruse; 7 deg. cent. (12.6 deg. fahr.) for Kennedy; and — 14 deg. cent. (— 25.2 deg. fahr.) for Wilson and Barnard.

The ratios given in Table 7 are the averages of the ratios obtained for a number of gasolines in each case. Careful analysis of the individual ratios for any mixture indicated that there was no definite trend of the

TABLE 5—EQUILIBRIUM-SOLUTION TEMPERATURES

	Temperature							Normal Dew-Point Observed	
	Vapor		Liquid		Average				
Fuel	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	$T_{90\ Per\ Cent\ ASTM}/T_{ES}$	Deg. Cent.	Deg. Fahr.
A	150	302	163	325	156.5	313.7	1.091	156.6	313.9
C	134	273	143	289	138.5	281.3	1.086	138.4	281.1
E	155	311	167	333	161.0	321.8	1.087	161.7	323.1
F	152	306	168	331	160.0	320.0	1.087	160.0	320.0
RPC	150	302	166	332	158.0	316.4	1.092	162.2	324.0
						Average	1.089 ± 0.003		

TABLE 7—COMPARISON WITH RATIOS BETWEEN NORMAL DEW-POINT TEMPERATURES AND DEW-POINT TEMPERATURES OF VARIOUS AIR-FUEL MIXTURES COMPUTED FROM DATA PUBLISHED BY OTHER OBSERVERS

Mixture	Observer[23]	Method[24]	Ratio, Observed	Ratio, Calculated	Difference	Samples
1–1	B. of S.	D. P. A.	1.113 ± 0.003	1.118	—0.005	5
	S. & B.	D. P. A.	1.114 ± 0.017	....	—0.004	7
2–1	B. of S.	D. P. A.	1.157 ± 0.004	1.161	—0.004	5
	S. & B.	D. P. A.	1.162 ± 0.011	....	0.001	7
3–1	S. & B.	D. P. A.	1.189 ± 0.012	1.189	0.000	7
4–1	B. of S.	D. P. A.	1.207 ± 0.004	1.209	—0.002	5
	S. & B.	D. P. A.	1.209 ± 0.013	....	0.000	7
5–1	S. & B.	D. P. A.	1.227 ± 0.014	1.224	0.003	7
6–1	S. & B.	D. P. A.	1.242 ± 0.014	1.237	0.005	7
8–1	B. of S.	D. P. A.	1.250 ± 0.006	1.258	—0.008	5
	B. of S.	E. A. D.	1.268 ± 0.007	....	0.010	19
9–1	S. & B.	D. P. A.	1.267 ± 0.015	1.267	0.000	7
12–1	B. of S.	E. A. D.	1.291 ± 0.005	1.287	0.004	21
	S. & B.	D. P. A.	1.284 ± 0.013	....	—0.003	7
	Brown	E. A. D.	1.296 ± 0.008	....	0.009	26
	Gruse	E. A. D.	1.246 ± 0.011	....	(—0.041)	5
	Kennedy	P. & M. W.	1.256 ± 0.011	....	(—0.031)	6
	W. & B.	E. S.	1.339 ± 0.017	....	(0.052)	14
15–1	S. & B.	D. P. A.	1.301 ± 0.011	1.304	—0.003	7
	Gruse	E. A. D.	1.274 ± 0.005	....	(—0.030)	4
	Kennedy	P. & M. W.	1.279 ± 0.012	....	(—0.025)	6
	W. & B.	E. S.	1.360 ± 0.016	....	(0.056)	14
16–1	B. of S.	D. P. A.	1.301 ± 0.006	1.308	—0.007	4
	B. of S.	E. A. D.	1.312 ± 0.006	....	0.004	21
18–1	S. & B.	D. P. A.	1.315 ± 0.011	1.317	—0.002	7
20–1	B. of S.	E. A. D.	1.334 ± 0.008	1.325	0.009	21
21–1	S. & B.	D. P. A.	1.322 ± 0.012	1.328	—0.006	7
24–1	S. & B.	D. P. A.	1.330 ± 0.011	1.338	—0.008	7
27–1	S. & B.	D. P. A.	1.338 ± 0.009	1.346	—0.008	7
30–1	S. & B.	D. P. A.	1.345 ± 0.010	1.354	—0.009	7

[23] *Observers:*—B. of S., Bureau of Standards; S. & B., Stevenson and Babor; W. & B., Wilson and Barnard.

[24] *Methods:*—D. P. A., Dew-Point Apparatus with Platinum Black Surface; E. A. D., Equilibrium Air-Distillation; P. & M. W., Pressures of Gasoline Vapor and Molecular Weights; E. S., Measurements on Equilibrium Solutions.

ratios and, although small consistent deviations from the averages were observable in the case of a few gasolines, there did not appear to be any real justification for assuming a relation between the temperature ratios and the normal dew-points or the 90 per cent A.S.T.M. points. An alternative method of stating this is that the dew-point of any mixture can be represented as a linear function of the normal dew-point or the 90 per cent A.S.T.M. point. This conclusion is at variance with the curves published by Stevenson and Stark and later given by Stevenson and Babor in modified form. These investigators considered that a linear function did not give as good a reproduction of the data as a function of higher order. This point is illustrated in Fig. 4 where the values of the Bureau of Standards and of Stevenson and Babor for a 12-1 mixture are represented. A straight line is seen to reproduce the points with considerable accuracy, although a slightly curved line might give a little better reproduction.

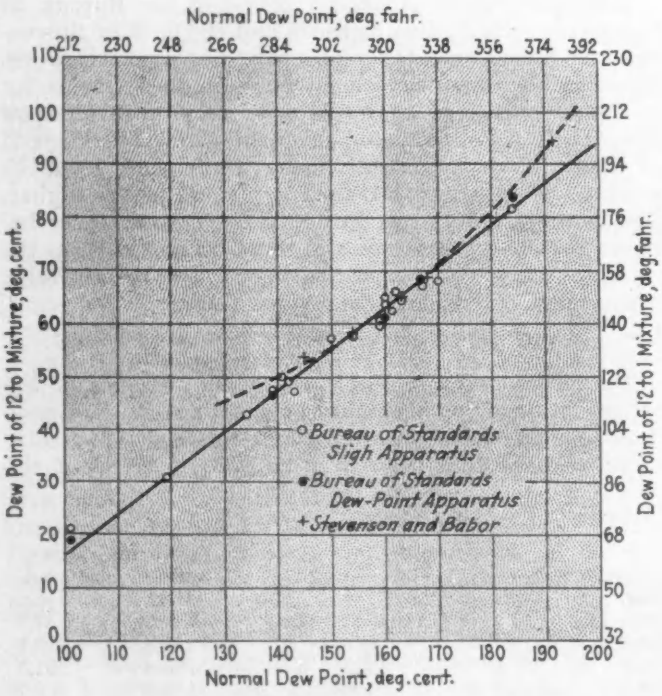

FIG. 4—RELATION BETWEEN THE DEW-POINTS OF 12-1 MIXTURES AND THE NORMAL DEW-POINTS

In view of the fact that the equation of the straight line is $T_{NDP}\ /T_{DP} = 1.290$ and that the equation of the curve, if used, would be much more complicated, it seems advisable to adopt the simpler relation, particularly since the loss in accuracy is very slight and is within the experimental error of the measurements. The dotted curved line is the one proposed by Stevenson and Babor and, although it reproduces the dew-points very well over part of the range, it appears to have too large a curvature. If extrapolated, apparently it would result in very large errors. This plot for a 12-1 mixture is typical of all studied, so that, for every mixture, there is a specific constant relating the absolute temperature of the dew-point of any air-gasoline mixture to the absolute temperature of the normal dew-point or of the 90 per cent A.S.T.M. point of the same gasoline, and these ratios appear to be independent of the particular gasoline.

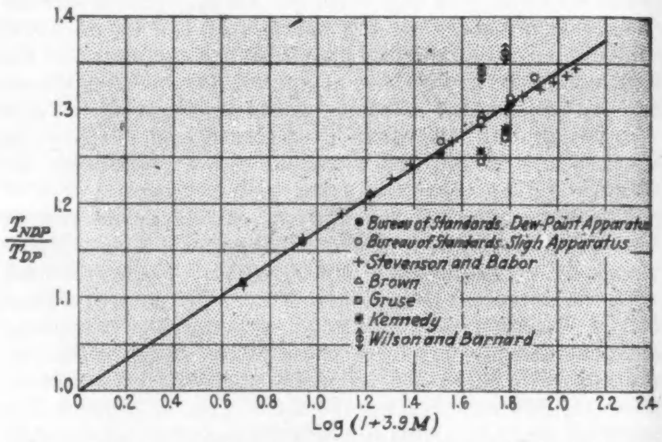

FIG. 5—RELATION BETWEEN TEMPERATURE RATIO AND AIR-FUEL MIXTURE

RELATION BETWEEN DEW-POINT RATIOS AND AIR-FUEL MIXTURES

A study of the temperature ratios for the various air-fuel mixtures showed that it was possible to obtain an analytical relation between temperature ratio and mixture. Equation (1) shows this relation when the normal dew-point is used as a reference state, while equation (2) holds when reference is made to the 90 per cent A.S.T.M. temperature.

$$T_{NDP}\ /\ T_{DP} = 1 + 0.1707 \log\,(1 + 3.9\,M) \qquad (1)$$

$$T_{90\ per\ cent\ ASTM}\ /\ T_{DP} = 1.084 + 0.1850 \log\,(1 + 3.9\,M) \qquad (2)$$

The average deviation between the ratios computed from equation (1) and the observed values of the Bureau of Standards by two methods and those calculated from the data of Stevenson and Babor is ± 0.004, which is equivalent to about ± 0.3 per cent. A plot of these temperature ratios against the logarithmic function of

mixture ratio is shown in Fig. 5 to illustrate the agreement of the observed values with the equation.

Numerical computation of the dew-points by means of equations (1) or (2) can be obviated by the use of the alignment chart shown in Fig. 6. On the left side of the duplex scale are represented 90 per cent A.S.T.M. temperatures in degrees centigrade, while on the right side of this scale are the corresponding normal dew-point temperatures. From this scale alone, the normal dew-point of any gasoline can be estimated accurately if the 90 per cent A.S.T.M. point is known. The middle scale represents mixture ratios, while the dew-point temperatures are indicated on the scale at the right. To determine the dew-point temperature of any mixture of a given gasoline with air, connect by means of a straight edge the 90 per cent A.S.T.M. temperature, or the normal dew-point temperature, with the point on the middle scale representing the mixture ratio of interest and extrapolate the line to the scale on the right. The intersection is the dew-point temperature of the particular mixture for the gasoline in question.

Relation Between Dew-Point Ratios and Partial Pressures

It is an experimental fact that over the range from 20 to 760-mm. pressure, the logarithm of the vapor pressure of any pure hydrocarbon is essentially a linear function of $1/T$ where T is the absolute temperature. While it has not been deduced rigorously that a similar relation holds for the partial pressures of the gasoline vapor along the dew-point line, it seems reasonable that such should be the case.

If it is assumed that the gasoline vapor and the air obey the perfect gas law, then

$$p_a = W_aRT/M_aV \qquad (3)$$
$$p_f = W_fRT/M_fV \qquad (4)$$

where p_a and p_f are the respective partial pressures in millimeters of mercury of the air and fuel vapor in any gaseous mixture, W_a and W_f are their respective masses in grams, M_a and M_f are their respective molecular weights, V and T are the volume and absolute temperature of the mixture, and R is the usual gas-constant. The molecular weight of the fuel vapor, M_f, is a constant for all mixtures of a particular gasoline since, along the dew-point line, the composition of the vapor remains unchanged.

Combination of equations (3) and (4) gives

$$p_a/p_f = W_aM_f/W_fM_a \qquad (5)$$

In addition, if the dew-point measurements are conducted at a total pressure of one atmosphere, 760 mm. of mercury, then

$$p_a + p_f = 760 \qquad (6)$$

Substituting in equation (5) the value $(760 - p_f)$ for p_a and the mixture ratio M for W_a/W_f, there results

$$760/p_f = 1 + M\ (M_f/M_a) \qquad (7)$$

Taking logarithms of both sides, equation (7) becomes

$$\log\ (p_f/760) = -\log\ (1 + M\ (M_f/M_a) \qquad (8)$$

From the experimental dew-point data, it was found for equation (1) that

$$T_{NDP}/T_{DP} = 1 + 0.1707 \log\ (1 + 3.9\,M) \qquad (1)$$

In equation (1), the factor 3.9 can be considered equal to M_f/M_a for, if the molecular weight of air is taken as 28.95, M_f becomes 112.9, which is close to the molecular weight of octane, namely, 114.1, and represents a fair average value for most commercial gasolines. It is probable that replacing the numerical factor 3.9 by M_f/M_a would make equation (1) more accurate; but, for a 16-1 mixture, variation in the molecular weight of the fuel from 100 to 120 would only change T_{NDP}/T_{DP} from 1.299 to 1.314 and for richer mixtures the variation would be less. In view of this, the experimentally determined equation (1) seems to be sufficiently accurate for practical purposes for all gasolines except very extreme samples and, in any case, the equation reproduces the experimental data, which is the real criterion.

Substituting M_f/M_a for 3.9 in equation (1) for theoretical purposes, it becomes

$$T_{NDP}/T_{DP} = 1 + 0.1707 \log\ (1 + M\ (M_f/M_a)) \qquad (9)$$

Combination of equations (8) and (9) then gives

$$\log\ (p_f/760) = 5.86\ (1 - T_{NDP}/T_{DP}) \qquad (10)$$

which is analogous to the expressions obtained for the vapor pressures of pure hydrocarbons. The factor 5.86 is the reciprocal of the number 0.1707 in equations (1) and (9).

To test relation (10), it is necessary to determine the molecular weights of the fuels for which dew-point data were obtained in terms of mixture ratios.

Molecular-Weight Determinations

The ordinary Beckmann method, employing the lowering of the freezing point of benzene, was chosen as the simplest and most accurate method for determining the molecular weights of the gasolines. This apparatus is so well known that a description seems unnecessary. A calibrated Beckmann thermometer was used for measuring the temperature change.

The benzene employed was carefully purified, except that no precautions were taken to remove dissolved air, which seems to be unnecessary. A sample of "C.P., thiophene-free" benzene was shaken with four or five successive portions of concentrated sulphuric acid to remove the remaining thiophene. Then followed several washings with a solution of sodium hydroxide, followed by a similar procedure with distilled water. The benzene was subsequently dried with calcium chloride and metallic sodium and was then distilled. A small portion, about 50 ml., of the distillate that first came over was discarded, as was also the last 50 ml. remaining in the distillation flask. The main portion of the benzene, about 800 ml., distilled over at temperatures between 79.89 and 79.92 deg. cent. (175.80 and 175.86 deg. fahr.) at a pressure of 752 mm. The distillate was stored over metallic sodium.

In making a measurement, the outer bath was filled with ice and water so that a temperature of 2 to 3 deg. cent. (35 to 37 deg. fahr.) was obtained. Then, 10 ml. of benzene was introduced into the inner freezing-tube which was then immersed in the ice bath and the benzene was stirred until solid began to separate. The tube was removed from the ice bath, dried and placed in position in the air mantle. The mixture of solid and liquid benzene was stirred slowly until the thermometer indicated a constant temperature. The tube was then removed and warmed with the hand until, on stirring, the solid melted and the temperature was raised about 0.5 deg. cent. (0.9 deg. fahr.) above the preliminary freezing-point value, after which the tube was replaced in the air mantle. The liquid benzene was allowed to supercool about 0.3 to 0.5 deg. cent. (0.54 to 0.90 deg. fahr.) below the preliminary freezing-point temperature and was then stirred, which caused formation of solid. As soon as the solid phase appeared, the tempera-

TABLE 8—EFFECT OF CONCENTRATION OF THE BENZENE SOLUTION ON THE COMPUTED MOLECULAR WEIGHT OF THE FUEL

Fuel	Weight of Benzene, Grams	Weight of Gasoline, Grams	Molecular Weight
A	8.79	0.0768	119.8
		0.1536	119.0
		0.2304	120.3
C	8.79	0.0741	113.8
		0.1482	113.1

ture rose to a point where it remained constant. This temperature was taken as the freezing point of the pure benzene. The tube was removed and heated with the hand until the solid melted, after which 0.1 ml. of gasoline was introduced by means of a calibrated micropipette, care being taken that none of the gasoline was deposited on the walls of the freezing-point tube above the surface of the benzene. Mixing was effected by stirring, and then the initial freezing-point of solution was determined in the same manner as was used with the pure benzene. In the case of the solution, however, the temperature rose after supercooling to a point where it remained constant for a short period, after which it fell slowly. The maximum temperature recorded by the thermometer was taken as the freezing-point of the solution. Several determinations were made of the freezing point of the pure benzene and of each solution.

The relation used for computing the molecular weights from the temperature readings is as follows:

$$M_f = 5120\, V_f d_f / V_b d_b (\Delta T) \quad (11)$$

where V_f and V_b are the volumes of gasoline and benzene used, d_f and d_b are their respective densities, and ΔT is the difference in temperature between the freezing points of pure benzene and the solution. This formula is based on the assumption that gasoline forms an ideal solution with the benzene, which is reasonable. As a test of this assumption, in the case of several fuels, successive portions of gasoline were added to the benzene and the freezing point of each solution was measured. Two typical series of results are shown in Table 8, and it is seen that concentration of the solution has apparently no effect upon the value of the molecular weight computed from relation (11).

The experimental constant 5120 is the one ordinarily employed when benzene is used as a solvent. To verify the correctness of this value, a series of determinations was made on the molecular weight of pure toluene. The mean of five values computed by relation (11) was 92.1 ± 0.2, being in excellent agreement with the theoretical value, 92.06.

The possibility of serious loss of either solute or solvent by volatilization during the experiment was investigated by taking a series of readings on the same solution over a period of several hours. This test in-

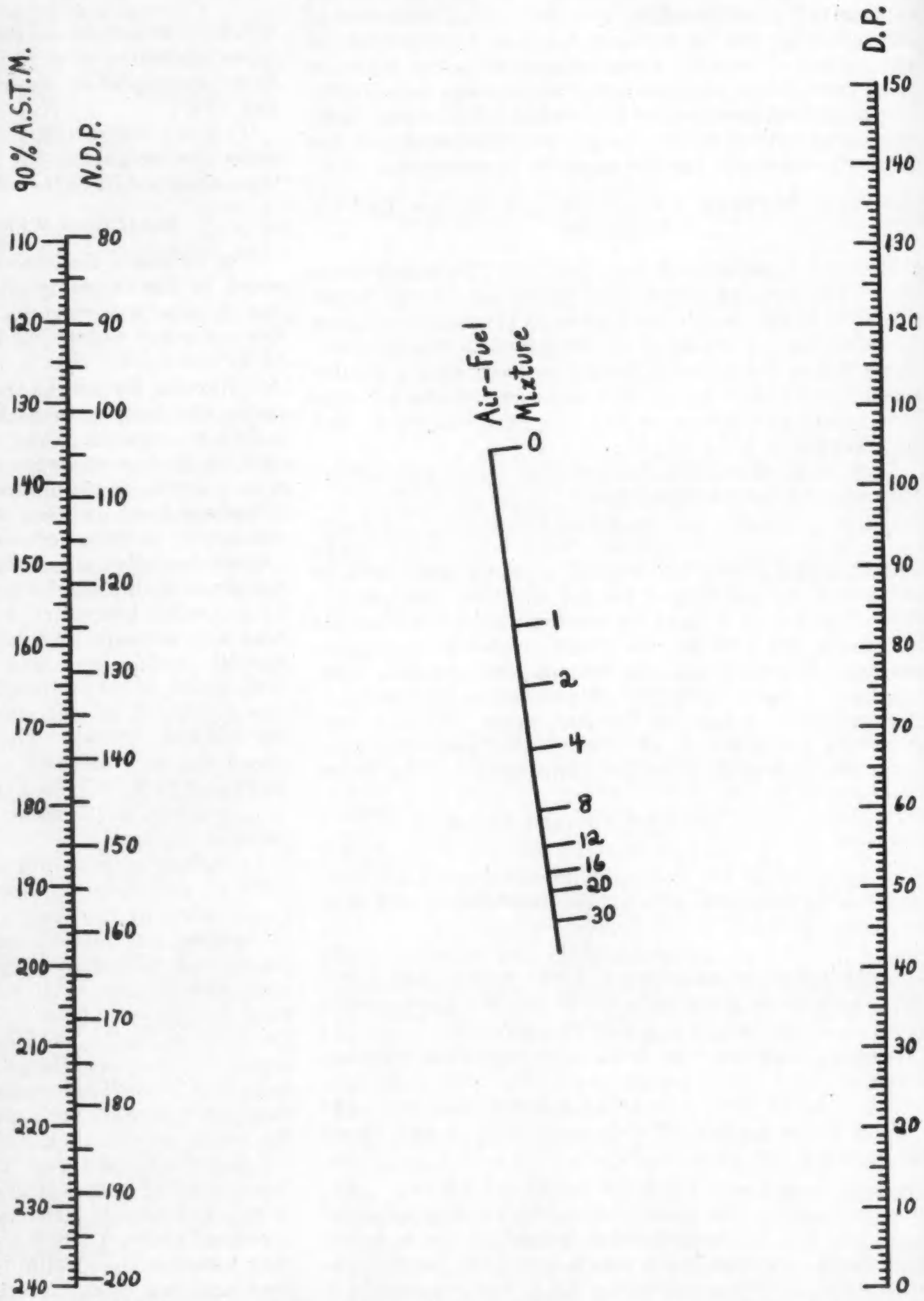

FIG. 6—TEMPERATURE-CONVERSION CHART FOR DEW-POINTS OF AIR-FUEL MIXTURES

dicated that no appreciable loss occurred during the time normally required to make a measurement.

It is obvious that with benzene as a solvent, this method for the determination of molecular weights of gasoline cannot be used with benzol blends. So far as is known, none of the samples tested contained any appreciable amounts of benzene.

Molecular-weight values on 24 gasolines were obtained and are shown in Table 9. Samples *SA* to *SG* inclusive are the same gasolines as were used by Stevenson and Babor in their dew-point work and were very kindly given to the Bureau by Professor Stevenson. A comparison of the molecular weight and density values for the 24 gasolines indicated that the molecular weights could be computed approximately from the density by means of the simple relation

$$M_f = 39\, d_f/(1 - d_f) \qquad (12)$$

where d_f is the density of the gasoline at 60 deg./60 deg. The average deviation between observed and calculated values was $\pm$ 4.4. No claim is made for the accuracy of equation (12), but it does furnish a simple method for obtaining approximate values of the molecular weights. It is more convenient than the Wilson and Barnard rule for obtaining molecular weights from the mean boiling-points, which gives about the same accuracy, $\pm$ 5.0, for these samples. Equation (12) can be written in the very simple form $M_f = V - 39$, where V is the molecular volume of the gasoline.

Test of the Relation Between Dew-Point Ratios and Partial Pressures

In Table 5 dew-points obtained with the modified Stevenson and Babor apparatus were given for gasolines *A*, *B*, *C*, *J* and *M*, corresponding to mixture ratios of 1-1, 2-1, 4-1, 8-1 and 16-1. In Table 1, the dew-points of these same gasolines obtained with the Sligh apparatus were given for the mixtures 8-1, 12-1, 16-1 and 20-1. Using equation (7) and the molecular weights of these fuels, the partial pressure of the gasoline vapor for each mixture and fuel was computed. For each gasoline, a plot was made of the logarithm of the partial pressures against the reciprocal of the absolute dew-point temperatures, and on each plot were inserted the corresponding values for the normal dew-point, which were measured at a pressure of one atmosphere of gasoline vapor. A study of these plots showed that in every case a straight line through the points would reproduce the data within experimental error. The equations for these lines were of the form

$$\log p_f = -(A/T) + B \qquad (13)$$

where A and B are individual constants for each gasoline. Since these lines went through the normal dew-points, substitution of 760 for p_f, and T_{NDP} for T in equation (13) gives

$$\log 760 = -(A/T_{NDP}) + B \qquad (14)$$

Subtracting equation (14) from (13) and rearranging, leads to the relation

$$\log (p_f/760) = (A/T_{NDP})\ [1 - (T_{NDP}/T)] \qquad (15)$$

For each gasoline, the constant A, which is the slope of the log p_f, $1/T$ line with sign reversed, was obtained and was divided by the absolute normal dew-point temperature. The dew-point data of Stevenson and Babor were treated in a similar manner, using the molecular weights for *SA* to *SG* given in Table 9. In the case of these latter data, three plots indicated a slight curvature in the direction common to all pure hydrocarbons, three were linear, and one indicated curvature in the opposite direction. The best straight lines were put through the points in every plot, and the value of A obtained.

The values of A/T_{NDP} obtained from the linear plots of these 12 gasolines are given in Table 10, together with the corresponding normal dew-points and the molecular weights. There is a little variation in the values of A/T_{NDP}, but there is no apparent trend with either normal dew-point or molecular weight. Part of the variation is due to the uncertainty in drawing the best line through the points, which amounts to about $\pm$ 0.05 in A/T_{NDP}. The average value 5.85 is in excellent agreement with the factor 5.86 predicted from equation (10). The value 6.24 for gasoline *SG* was omitted in taking the average, since it appeared to be obviously in error.

TABLE 9—MOLECULAR WEIGHTS OF GASOLINES

Fuel	Molecular Weight	Density, 60 Deg./60 Deg.	Mean Boiling-Points, Deg. Cent.	Mean Boiling-Points, Deg. Fahr.
A	119.5 ± 0.9	0.768	136	277
B	102.7 ± 0.1	0.714	99	210
C	113.6 ± 0.7	0.741	118	244
J	111.5 ± 0.8	0.751	133	271
M	126.0 ± 0.4	0.776	154	310
P	92.1 ± 0.1	0.692	83	281
Q	180.2 ± 0.6	0.813	230	446
D	117.8 ± 0.6	0.754	117	243
E	125.4 ± 0.4	0.762	139	282
F	123.7 ± 0.4	0.766	150	302
K	118.3 ± 0.3	0.735	121	250
L	126.8 ± 0.4	0.751	129	264
N	131.6 ± 0.1	0.771	150	302
O	128.2 ± 0.7	0.755	145	293
RPC	115.0 ± 0.4	0.747	133	271
RH	109.5 ± 0.4	0.739	126	259
RL	107.3 ± 0.2	0.724	106	223
SA	108.4 ± 0.4	0.735	126	259
SB	111.6 ± 0.6	0.740	131	268
SC	110.1 ± 0.1	0.750	130	266
SD	109.0 ± 0.3	0.732	129	264
SE	108.8 ± 0.3	0.747	129	264
SF	114.2 ± 0.1	0.750	141	286
SG	118.1 ± 0.3	0.756	152	306

TABLE 10—VALUES OF A/T_{NDP}

Fuel[25]	A/T_{NDP}	T_{NDP} Deg. Cent.	T_{NDP} Deg. Fahr.	Molecular Weight
A	5.95	156.6	313.9	119.5
B	5.87	101.2	214.2	102.7
C	5.86	138.4	281.1	113.6
J	5.91	164.8	328.6	111.5
M	5.87	186.8	368.2	126.0
SA	5.94	144.7	292.5	108.4
SB	5.73	154.0	309.2	111.6
SC	5.80	154.0	309.2	110.1
SD	5.80	154.0	309.2	109.0
SE	5.74	163.4	294.1	108.8
SF	5.84	166.6	331.9	114.2
SG	(6.24)	191.9	377.4	118.1
Average	5.85 ± 0.06			

[25] Values of *SA* to *SG* are based on dew-point data of Stevenson and Babor.

Summary and General Conclusions

The dew-point measurements of the Bureau of Standards by three independent methods show good agreement with one another, and also agree closely with values obtained by Stevenson and collaborators. The use of the equilibrium-solution method for the determination of the normal dew-point is not considered to be accurate, although, if precautions are taken to pre-

vent undue superheating and if the mean of the indicated liquid and vapor temperatures is used, the results are in fair agreement with those obtained by other methods. The normal dew-point appears to be computable with accuracy from the 90 per cent A.S.T.M. point by means of the ratio 1.084, if both temperatures are expressed in absolute degrees. By the use of a simple chart or equation, the dew-point of any air-fuel mixture at a total pressure of one atmosphere can be obtained from the normal dew-point or from the 90 per cent A.S.T.M. point. Another simple relation permits the partial pressure of the gasoline vapor to be calculated at any desired temperature below the normal dew-point. An approximate equation is given for the estimation of the molecular weights of gasolines from their densities. In view of the diversity of gasolines employed in this work and the accuracy of the relations deduced, it seems apparent that the dew-points of any gasoline commercially available at present can be obtained directly from the 90 per cent A.S.T.M. temperature, corrected for loss, either in terms of air-fuel mixtures at a total pressure of 760 mm. of mercury or in terms of the partial pressures of the gasoline vapor.

From these results it appears that the 90 per cent A.S.T.M. temperature is a real criterion of the volatility, which is of interest under normal operating conditions with an engine. Lower 90-per cent points indicate greater ease of evaporation in the manifold, and a classification of gasolines on the basis of this point would give real information suitable for the selection of fuels best adapted to particular designs of engine manifolds. The end-point on the A.S.T.M. distillation curve is frequently used for this purpose, but it is misleading as a criterion of complete volatility since it does not correspond to any definite percentage evaporated.

It may happen that two gasolines have the same 90 per cent A.S.T.M. temperature, when corrected for loss, and still one may be a "400 end-point" and the other a "450 end-point" gasoline. However, according to the results obtained in the present investigation, both would have the same volatility under normal operating conditions. On the other hand, two gasolines may have the same end-point and yet they will have different volatilities under normal operating conditions if their 90-per cent points are different.

APPENDIX 1

Dew-Points of Air-Fuel Mixtures at any Total Pressure

The equations given in the body of the report for air-fuel mixtures apply to a total pressure of one atmosphere; but, with slight modification, they can be used to express the equilibrium vaporization at any reduced pressure such as might exist in the engine manifold. Equation (6) can be written in the general form

$$p_a + p_f = P \tag{16}$$

where P is the total pressure of the mixture. Substitution in equation (5) leads to the relation

$$P/p_f = 1 + M\,(M_f/M_a) \tag{17}$$

Taking logarithms of both sides, equation (17) becomes

$$\log p_f = \log P - \log\,[1 + M\,(M_f/M_a)] \tag{18}$$

If log 760 is subtracted from both sides, equation (18) can be written

$$\log\,(p_f/760) = \log\,(P/760) - \log\,[1 + M(M_f/M_a)] \tag{19}$$

Substituting for log $(p_f/760)$ from equation (10), there results

$$T_{NDP}/T_{DP} = 1 + 0.1707 \log\,[(1 + M(M_f/M_a)\,(760/P)] \tag{20}$$

where T_{DP} is the dew-point of the particular mixture at any pressure P, and T_{NDP} is the normal dew-point at a pressure of one atmosphere.

For all practical purposes, the value of M_f given in equation (12) can be used, making it necessary to know the density only.

$$T_{NDP}/T_{DP} = 1 + 0.1707 \log\,[(1 + 1.347\,M\,d_f/1 - d_f)\,760/P] \tag{21}$$

where 1.347 is equal to $39/M_a$, the molecular weight of air being taken as 28.95.

In accordance with the experimental fact that M_f/M_a can be considered equal to 3.9 for all the gasolines considered in this work, equation (20) can be written

$$T_{NDP}/T_{DP} = 1 + 0.1707 \log\,[(1 + 3.9\,M)\,\,(760/P] \tag{22}$$

In these equations $\dfrac{90 \text{ per cent ASTM}}{1.084}$ can be substituted for T_{NDP}.

To illustrate the application of these equations two cases will be considered. For a 12-1 mixture of U. S. Motor gasoline with air, the dew-point at a pressure of one atmosphere computed by equation (22) is 66 deg. cent. (151 deg. fahr.) while at a pressure of ½ atmosphere it is 54 deg. cent. (129 deg. fahr.). On the other hand, equation (22) leads to the conclusion that a 12-1 mixture would just be completely vaporized at 94 deg. cent. under a pressure of one atmosphere, whereas, at the same temperature and a pressure of ½ atmosphere, complete vaporization would just occur with a 5.87-1 mixture. Similar results would be obtained with equations (20) and (21), and problems similar to the ones illustrated can be solved readily for any reduced pressure and for any mixture ratio.

APPENDIX 2

Correlation of Equilibrium Air-Distillation and A.S.T.M. Distillation Data

At the 1928 Annual Meeting of the Society, a report was given on a correlation of the equilibrium air-distillation data obtained with the Sligh apparatus and the A.S.T.M. distillation curves of the same fuels. This preliminary report was based on results for 15 gasolines, data for 12 samples being presented in tabular form and for three gasolines in graphical form. Since that time, information on 10 additional gasolines has been obtained. Good agreement is shown between the temperature ratios for these latter samples and the ratios previously reported. Since these 25 gasolines cover the range on the market at present, it seems reasonable to assume that the averages of the temperature ratios are applicable to all commercial gasolines.

Table 11 contains a description of the gasolines studied. There are five cracked gasolines, one aviation, two U. S. Motor, one blend with motor benzol, two blends with C. P. benzene and one blend with kerosene. No information is available on the composition of the other samples. In addition, three gasolines, *RH*, *P* and *Q* are included, which were used only in the dew-point and the molecular-weight work.

Table 12 contains specification data for the 25 gasolines. The ranges are as follows:

	Deg. Cent.	Deg. Fahr.
Initial Boiling-Point	30 to 112	80 to 234
20 Per Cent	80 to 127	176 to 261
50 Per Cent	102 to 164	216 to 327
90 Per Cent	136 to 224	277 to 435
End Point	155 to 263	311 to 505

TABLE 11—DESCRIPTION OF GASOLINE SAMPLES

Fuel	Source	Remarks
1, 2, 3	Atlantic Refining Co.	Straight Run
1A, *2A*, *3A*, *4A*	Atlantic Refining Co.	Special blends for starting tests.
6A	Bureau of Standards	Current supply, U. S. Motor.
B	Army Air Corps	Domestic Aviation
C		Blend, 50 per cent of *A* and 50 per cent of *B*
D, *E*, *F*	The Texas Co.	Special blends for acceleration work
L	Standard Oil Co. of N. J.	Laurel Oil
RH, *RL*	Vacuum Oil Co.	Russian Naphthas—Grozny crude
RPC	Universal Oil Products Co. Dubbs Process cracked.	Midcontinent crude
J	Universal Oil Products Co. Dubbs Process cracked.	Smackover crude
K	Universal Oil Products Co. Dubbs Process cracked.	Panhandle crude
N	Universal Oil Products Co. Dubbs Process cracked.	California crude
O	Universal Oil Products Co. Dubbs Process cracked.	Wyoming crude
G		Blend, 60 per cent of No. 6 and 40 per cent of motor benzol
H		Blend, 80 per cent of *A* and 20 per cent of C. P. benzene
I		Blend, 60 per cent of *A* and 40 per cent of C. P. benzene
M		Blend, 80 per cent of *A* and 20 per cent of kerosene
P	Virginian Gasoline & Oil Co.	Tail Gasoline from pentane still
Q		Light kerosene

In Table 13 are listed the temperature ratios respectively for 20-1, 16-1, 12-1 and 8-1 resultant air-vapor mixtures for every 10 per cent to 90 per cent. These ratios are obtained by dividing the A.S.T.M. temperature in degrees absolute at a given percentage evaporated by the equilibrium air-distillation temperatures in degrees absolute for these four resultant-mixtures at the same percentage evaporated. At the bottom of each group are given the average ratios and the average deviations.

TABLE 13—TEMPERATURE RATIOS

Fuel	Percentage 10	20	30	40	50	60	70	80	90
			20-1 *Resultant Mixtures*						
1	1.34	1.35	1.36	1.37	1.39	1.40	1.41	1.42	1.45
3	...	1.33	1.37	1.39	1.40	1.41	1.42	1.43	1.46
1A	1.33	1.36	1.37	1.39	...	...	...	...	...
2A	1.32	1.36	1.37	1.39	...	...	...	...	...
3A	1.34	1.37	1.39	1.40	...	...	...	...	...
4A	1.33	1.37	1.38	1.39	...	...	...	...	...
A	...	...	1.38	1.39	1.40	1.40	1.42	1.44	1.47
B	...	...	...	1.37	1.39	1.40	1.41	1.43	1.48
C	...	...	...	1.38	1.38	1.39	1.40	1.43	1.48
D	1.32	1.36	1.38	1.39	1.39	1.39	1.39	1.40	1.50
E	1.33	1.35	1.37	1.38	1.38	1.39	1.41	1.44	1.48
F	1.33	1.35	1.37	1.39	1.39	1.40	1.40	1.41	1.45
RH	1.34	1.35	1.36	1.37	1.38	1.38	1.40	1.42	1.45
L	...	1.37	1.36	1.36	1.37	1.38	1.38	1.40	1.44
RPC	...	1.34	1.35	1.36	1.37	1.39	1.41	1.44	1.47
2	...	...	...	1.36	1.38	1.41	1.44	1.47	1.50
6	1.33	1.34	1.35	1.37	1.38	1.40	1.41	1.43	1.47
G	...	1.35	1.36	1.36	1.37	1.38	1.40	1.44	1.49
H	...	...	1.33	1.34	1.36	1.38	1.41	1.44	1.47
I	...	...	...	1.40	1.38	1.37	1.39	1.43	1.49
J	1.31	1.33	1.34	1.36	1.38	1.40	1.42	1.44	1.48
K	...	1.33	1.35	1.37	1.38	1.39	1.41	1.42	1.45
M	1.30	1.34	1.36	1.37	1.38	1.39	1.41	1.44	1.47
N	1.33	1.35	1.36	1.37	1.38	1.39	1.40	1.42	1.45
O	1.31	1.34	1.35	1.37	1.38	1.39	1.41	1.43	1.45
Average	1.326	1.349	1.362	1.376	1.381	1.391	1.407	1.430	1.469
Average △	0.010	0.010	0.011	0.013	0.007	0.008	0.009	0.011	0.014
			16-1 *Resultant Mixtures*						
1	...	1.34	1.35	1.36	1.37	1.38	1.39	1.40	1.43
3	...	1.32	1.35	1.37	1.38	1.39	1.40	1.41	1.44
1A	1.32	1.34	1.35	1.37	1.38	...	...	...	...
2A	1.30	1.33	1.35	1.36	1.38	...	...	...	...
3A	1.32	1.35	1.36	1.38	1.39	...	...	...	...
4A	1.31	1.35	1.36	1.37	1.38	...	...	...	...
A	...	...	...	1.38	1.38	1.39	1.40	1.42	1.45
B	...	...	...	...	1.37	1.37	1.38	1.40	1.43
C	...	...	...	...	1.37	1.37	1.38	1.40	1.45
D	1.29	1.33	1.35	1.37	1.38	1.38	1.37	1.38	1.48
E	1.29	1.33	1.35	1.36	1.37	1.37	1.39	1.42	1.46
F	1.29	1.31	1.34	1.36	1.37	1.38	1.38	1.39	1.43
RH	1.32	1.34	1.35	1.35	1.36	1.37	1.38	1.40	1.43
L	...	1.35	1.35	1.35	1.35	1.36	1.37	1.39	1.42
RPC	...	1.33	1.33	1.34	1.36	1.37	1.39	1.42	1.45
2	...	1.31	1.33	1.34	1.37	1.39	1.42	1.44	1.47
6	...	1.32	1.33	1.34	1.36	1.37	1.39	1.41	1.44
G	...	1.33	1.34	1.34	1.35	1.36	1.39	1.42	1.47
H	...	...	...	...	1.34	1.36	1.39	1.42	1.45
I	...	...	...	1.38	1.37	1.36	1.38	1.41	1.47
J	...	1.31	1.33	1.35	1.37	1.38	1.40	1.43	1.46
K	...	1.31	1.34	1.36	1.37	1.38	1.39	1.40	1.43
M	1.29	1.33	1.35	1.36	1.37	1.38	1.39	1.42	1.45
N	1.31	1.34	1.35	1.35	1.36	1.37	1.38	1.41	1.44
O	1.30	1.33	1.34	1.35	1.36	1.37	1.39	1.41	1.43
Average	1.304	1.330	1.345	1.359	1.369	1.374	1.388	1.410	1.451
Average △	0.011	0.010	0.008	0.011	0.008	0.008	0.008	0.011	0.014

TABLE 12—SPECIFICATION DATA FOR GASOLINES

Fuel Sample No.	Distillation Temperatures: Initial Boiling-Point Deg. Cent.	Initial Boiling-Point Deg. Fahr.	20 Per Cent Deg. Cent.	20 Per Cent Deg. Fahr.	50 Per Cent Deg. Cent.	50 Per Cent Deg. Fahr.	90 Per Cent Deg. Cent.	90 Per Cent Deg. Fahr.	End-Point Deg. Cent.	End-Point Deg. Fahr.	60 Deg./60 Deg. Specific Gravity	Loss, Per Cent	Residue, Per Cent
1	89	192	127	261	156	313	202	396	223	433	0.764	1.3	1.7
3	59	138	121	250	159	318	199	390	222	432	0.730	1.8	1.2
1A	50	122	104	219	141	286	202	396	226	439	0.733	2.3	1.7
2A	53	127	106	223	141	286	198	388	225	437	0.739	1.5	1.5
3A	58	136	110	230	141	286	196	385	218	424	0.738	1.0	2.0
4A	55	131	112	234	141	286	189	372	215	419	0.731	1.5	1.5
A	38	100	100	212	136	277	199	390	220	428	0.768	1.2	1.3
B	32	90	80	176	102	216	136	277	155	311	0.714	2.0	1.0
C	36	97	87	189	116	241	178	352	215	419	0.741	1.2	1.3
D	48	118	103	217	122	252	204	399	227	441	0.754	0.8	1.2
E	47	117	103	217	138	280	201	394	222	432	0.762	0.7	1.8
F	43	109	103	217	164	327	199	390	223	433	0.766	1.0	1.0
RH	51	124	99	210	126	259	169	336	204	398	0.739	0.5	1.1
L	112	234	118	244	126	259	152	306	180	356	0.751	0.3	1.2
RPC	38	100	88	190	135	275	200	392	222	432	0.747	1.0	1.5
2	45	113	74	165	113	235	198	388	224	435	0.730	1.4	1.6
6	58	136	107	225	139	282	192	378	222	432	0.768	1.0	1.0
G	65	149	92	198	108	226	181	358	216	421	0.807	1.0	1.5
H	47	117	85	185	114	237	191	376	213	415	0.776	1.8	1.2
I	56	132	83	181	95	203	183	361	210	410	0.805	1.7	1.3
J	30	86	80	176	138	279	210	410	224	435	0.751	1.6	1.4
K	36	97	85	185	123	253	178	352	204	399	0.735	1.0	1.2
M	47	117	111	232	153	307	224	435	263	505	0.776	0.7	1.3
N	60	140	114	237	151	304	205	401	221	430	0.771	0.6	1.2
O	46	115	103	217	148	298	201	394	216	421	0.755	0.6	1.4
RL	46	115	84	183	105	221	148	298	188	370	0.724	0.3	1.2
P	53	127	71	160	78	172	107	225	165	329	0.692	1.3	1.1
Q	180	356	209	408	226	439	268	514	304	579	0.813	0.8	1.2

TABLE 13—TEMPERATURE RATIOS (*Concluded*)

Fuel	Percentage 10	20	30	40	50	60	70	80	90
				12-1 Resultant Mixtures					
1	...	1.32	1.33	1.34	1.35	1.36	1.37	1.38	1.41
3	...	...	1.33	1.35	1.36	1.37	1.37	1.39	1.41
1*A*	1.30	1.32	1.33	1.35	1.36	1.37	...	...	...
2*A*	1.28	1.31	1.33	1.34	1.35	1.36	...	...	...
3*A*	1.30	1.33	1.34	1.35	1.36	1.38	...	...	...
4*A*	1.29	1.33	1.34	1.35	1.36	1.38	...	...	...
A	...	...	...	...	...	1.38	1.39	1.41	1.44
B	...	...	...	...	...	1.36	1.36	1.37	1.39
C	...	...	...	...	...	1.36	1.37	1.39	1.43
D	1.26	1.30	1.33	1.34	1.35	1.35	1.35	1.36	1.46
E	1.27	1.31	1.33	1.34	1.34	1.35	1.37	1.40	1.43
F	1.26	1.29	1.32	1.34	1.35	1.36	1.36	1.37	1.40
RH	...	1.32	1.33	1.33	1.34	1.35	1.36	1.38	1.41
L	...	1.33	1.33	1.33	1.33	1.34	1.35	1.37	1.40
RPC	...	1.31	1.32	1.32	1.34	1.35	1.37	1.39	1.42
2	...	...	1.31	1.32	1.34	1.37	1.39	1.42	1.46
6	...	1.30	1.32	1.32	1.34	1.35	1.36	1.38	1.42
G	...	...	1.32	1.33	1.33	1.34	1.36	1.40	1.45
H	...	...	...	...	...	1.34	1.36	1.40	1.43
I	...	...	...	1.35	1.34	1.34	1.36	1.39	1.44
J	...	...	1.31	1.34	1.35	1.37	1.39	1.41	1.44
K	...	...	1.32	1.34	1.35	1.36	1.37	1.39	1.42
M	1.27	1.31	1.33	1.34	1.35	1.35	1.37	1.39	1.43
N	1.29	1.32	1.33	1.33	1.34	1.35	1.37	1.39	1.42
O	...	1.31	1.33	1.34	1.35	1.36	1.37	1.39	1.42
Average	1.280	1.314	1.327	1.338	1.347	1.358	1.368	1.389	1.425
Average △	0.013	0.010	0.006	0.008	0.008	0.010	0.008	0.011	0.015
				8-1 Resultant Mixtures					
1	...	...	...	1.32	1.33	1.34	1.34	1.36	1.38
3	...	...	...	1.32	1.33	1.34	1.35	1.36	1.38
1*A*	1.26	1.29	1.31	1.32	1.33	1.34	1.35	1.36	1.39
2*A*	1.25	1.28	1.30	1.31	1.32	1.33	1.34	1.36	1.39
3*A*	1.28	1.30	1.31	1.32	1.33	1.34	1.35	1.36	1.39
4*A*	1.27	1.30	1.31	1.32	1.32	1.33	1.34	1.36	1.38
D	...	1.26	1.28	1.29	1.30	1.30	1.30	1.32	1.42
E	...	1.27	1.29	1.30	1.31	1.32	1.34	1.37	1.40
F	...	1.25	1.28	1.30	1.32	1.33	1.34	1.34	1.37
RH	...	...	...	1.30	1.31	1.32	1.33	1.35	1.38
2	...	...	...	1.29	1.31	1.33	1.36	1.39	1.42
6	...	...	1.29	1.30	1.32	1.33	1.34	1.36	1.39
G	...	...	...	1.30	1.30	1.31	1.33	1.37	1.42
J	...	...	...	1.32	1.34	1.36	1.37	1.39	1.42
K	...	...	...	1.31	1.32	1.33	1.34	1.36	1.39
M	...	...	...	1.30	1.31	1.32	1.34	1.36	1.40
N	...	...	...	1.31	1.32	1.33	1.34	1.36	1.39
O	...	...	...	1.30	1.32	1.33	1.35	1.36	1.39
Average	1.265	1.279	1.296	1.307	1.319	1.330	1.342	1.361	1.394
Average △	0.010	0.016	0.011	0.009	0.008	0.008	0.009	0.009	0.012

An equation has been obtained for the 16-1 temperature-ratios in terms of the percentage evaporated and is as follows:

$$R_{16} = 1.366 \pm (3.8 + 0.014\,P) \times 10^{-6}\,(P - 50)^2 \qquad (23)$$

where P is the percentage evaporated. The plus sign applies above and the minus sign below 50 per cent evaporated. It has been found further that the ratios for these various mixtures at the same percentage evaporated are related to one another in a simple manner, so that

$$R_{16} = 0.987\,R_{20} = 1.015\,R_{12} = 1.037\,R_8 \qquad (24)$$

These ratios in equation (24) are the same at all percentages evaporated. Table 14 shows the agreement between the observed values and those computed from equations (23) and (24).

TABLE 14—AVERAGES OF TEMPERATURE RATIOS

	Percentages 10	20	30	40	50	60	70	80	90
				For 20-1 Resultant Mixtures					
Observed	1.326	1.349	1.362	1.376	1.381	1.391	1.407	1.430	1.469
Calculated	1.320	1.346	1.366	1.380	1.384	1.389	1.403	1.428	1.466
Difference	0.006	0.003	–0.004	–0.004	–0.003	0.002	0.004	0.002	0.003
				For 16-1 Resultant Mixtures[26]					
Observed	1.304	1.330	1.345	1.359	1.369	1.374	1.388	1.410	1.451
Calculated	1.303	1.329	1.349	1.362	1.366	1.371	1.385	1.410	1.447
Difference	0.001	0.001	–0.004	–0.003	0.003	0.003	0.003	0.000	0.004
				For 12-1 Resultant Mixtures					
Observed	1.280	1.314	1.327	1.338	1.347	1.358	1.368	1.389	1.425
Calculated	1.283	1.309	1.329	1.341	1.345	1.350	1.364	1.389	1.425
Difference	–0.003	0.005	–0.002	–0.003	0.002	0.008	0.003	0.000	0.000
				For 8-1 Resultant Mixtures					
Observed	1.265	1.279	1.296	1.307	1.319	1.330	1.342	1.361	1.394
Calculated	1.256	1.281	1.300	1.313	1.317	1.322	1.335	1.359	1.395
Difference	0.009	–0.002	–0.004	–0.006	0.002	0.008	0.007	0.002	–0.001

[26] 16-1 Mixture. Temperature-Ratio = $1.366 \pm (3.8 + 0.014P) \times 10^{-6}\,(P - 50)^2$

$R_{16} = 0.987\,R_{20} = 1.015\,R_{12} = 1.037\,R_8$

Analyzing Distribution Costs

THE improvement in production methods during the last quarter century has not been accompanied by similar improvements in distribution methods, so that today the opportunity to discover real savings lies in the distribution of products rather than in their manufacture. Mass production has, moreover, added to the complexity of distribution problems.

There are already many evidences of experimenting in the field of distribution. There are chain stores, cooperative buying and selling, chains of departments in various separately owned department stores, direct selling, mail-order selling, installment selling, and so on. As has often been the case, these changes tending to upset habits of long standing have aroused strong antagonisms. There are proposals for legal steps to prevent some of these developments. It would seem reasonable to suggest that sound analysis should precede any drastic action.

It is obvious that there is no royal road to reduction of costs. The middleman's profit, for instance, cannot be eliminated. Someone has got to do those things which the wholesaler has done, if they are taken out of his hand. If the manufacturer or the mail-order house "sell direct," it must pay the costs of retailing. If one person is able to introduce more efficient methods, there is a real saving.

It seems there could be a great saving if we could eliminate the duplication of sales efforts of many salesmen trying to sell equivalent articles to the same retailer. Apparently, there is saving possible if selling in unprofitable territories can be eliminated. A certain hardware wholesaler, discovering his sales in certain areas were made at a loss, cut off about a quarter of his territory, as well as certain unprofitable accounts in the rest of his sales area. This reduced his gross sales about one-third, but his actual net profits were increased 35 per cent.

One of the fallacies in business today is the struggle for more and still more sales without regard for consequences. One concern, in its struggle for more business, doubled the number of its customers and got 15 per cent more business. Moreover, the credit bars had been lowered and these added customers were decidedly poorer risks than the other half. Increasing gross sales does not necessarily mean increasing profits.—From an address by Gorton James, chief of domestic commerce division, Bureau of Foreign and Domestic Commerce.

Factors Affecting Diesel-Engine Efficiency and Combustion

By A. E. Hershey[1]

Indiana Section Meeting *Illustrated with* Charts

CERTAIN theoretical phases of the subject are discussed by Mr. Hershey, who was associated with the investigation of internal-combustion-engine cycles which has been conducted for the last several years at the University of Illinois. In explanation of the objective of this discussion of Diesel-engine characteristics, he assumes that the primary interest of automotive engineers in the Diesel engine lies in its possible utilization as an automotive powerplant. He states that the use of this type of internal-combustion engine in general automotive service is still a somewhat remote possibility, but argues that, by a systematic study of both the Diesel and the Otto cycles, it is possible to obtain a much better understanding of the factors responsible for the particular characteristics of each. Once this point of advantage has been gained, it may be possible to combine the more desirable characteristics of each cycle and, by so doing, to develop new or slightly modified cycles which will meet present automotive requirements more satisfactorily than does either of the original cycles.

Associated with engines operating on the Diesel cycle are two characteristics which are generally regarded as being distinctive in the field of the internal-combustion engine. These are high thermal-efficiency and the ability to operate on relatively cheap, low-grade liquid fuels. It is these two factors of Diesel-engine performance which Mr. Hershey considers.

THROUGHOUT this paper, the method used for determining internal-combustion-engine efficiencies and temperatures is one developed by Prof. G. A. Goodenough several years ago[2]. It will suffice to state here that, at each point in an internal-combustion-engine cycle, four variables must be evaluated to describe completely the state of the working medium; namely, the volume, the pressure, the temperature and the composition of the gases undergoing the cyclic change. To evaluate these variables we must have at least four equations. The volume of the gases usually is determined by the combustion space in the engine, which changes in some regular way with the crank linkage of the engine. The three other variables must be determined by a simultaneous solution of the gas equation, the energy equation and some chemical-equilibrium equation. While such a solution always is possible, it is not always very simple and frequently can be arrived at only by successive approximations. The results found by this method give slightly higher temperatures and efficiencies than those observed in actual engines, but they give much closer agreement than any of the other theoretical analyses, and the efficiencies in most cases differ by only a few per cent.

Influence of Compression Ratio

Before considering the results of the application of this analysis to the Diesel cycle, the influence of compression ratio on engine efficiency, common to both the Diesel and the Otto cycles, can be discussed profitably. In considering internal-combustion-engine cycles, the combustion process is very likely to obtrude itself and cause us to lose sight of the fact that, after all, the internal-combustion engine is only a heat engine doing work by means of the expansion of heated gases. The heating of the gases within the engine cylinder is an additional function which has been imposed upon the engine from practical considerations based upon more rapid and efficient heat transfer. One of the most typical examples of this oversight is the generally accepted statement that increasing the compression results in an increase in thermal efficiency. So well established is this important relation between compression ratio and thermal efficiency, by both theoretical and experimental investigations, that it is usually accepted as one of the basic principles of internal-combustion-engine design.

By definition, the thermal efficiency of any cycle is the ratio of the work done in passing around the cycle to the available energy at the beginning of the cycle. Thus, for any internal-combustion cycle:

$$e_t = \frac{{}_1W_4}{H} \qquad (1)$$

where ${}_1W_4$ is the work done and H is the heating value of the combustible mixture at the beginning of the cycle. Considering an ideal cycle and disregarding heat loss, equation (1) can be written:

$$e_t = \frac{U_1 - U_4}{H} \qquad (2)$$

where U_1 is the energy of the combustible mixture at the beginning of the cycle, and U_4 is the energy of the products of combustion when ejected from the engine. If heat loss occurs during the cyclic process, an additional term, the energy rejected to the cooling system, must be subtracted from the available energy, U_1. In any event, all these energy terms can be expressed as functions of the absolute temperatures of the gases. The first term, U_1, is rather definitely fixed for most fuels and engines, but the U_4 term can vary widely, depending upon the temperature of the gases at the end of the expansion process. Let us see what effect varying the compression ratio will have on the temperature at the end of combustion and at the end of expansion.

Compression ratios varying from 4:1 to 17:1 have been considered to include the range of ratios com-

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[2] See Bulletins Nos. 139 and 160 of the Engineering Experiment Station of the University of Illinois, Urbana, Ill.

monly used for both the Otto and the Diesel cycles. The curves in Fig. 1 show the variation of combustion temperature and exhaust temperature with compression-ratio changes, and from them it can be seen that increasing the compression ratio from 4 to 8 increases the combustion temperature for the Otto cycle about 170 deg. fahr., while it lowers the exhaust temperature about 530 deg. Likewise, increasing the compression ratio of a Diesel cycle from 8 to 17 increases the combustion temperature 240 deg. fahr. and lowers the exhaust temperature 485 deg.

Since it has been shown how the efficiency of each cycle depends upon the exhaust temperature, it is evident that the improved efficiency resulting from higher compression-ratios is not caused by the combustion starting from higher initial pressures but rather by the products of combustion being expanded more completely, thus lowering their temperature and converting a larger portion of their thermal energy into useful work. In other words, it is the greater expansion-ratio and not the greater compression-ratio which is responsible for the higher thermal-efficiency, and it is logical to ask: What of it?

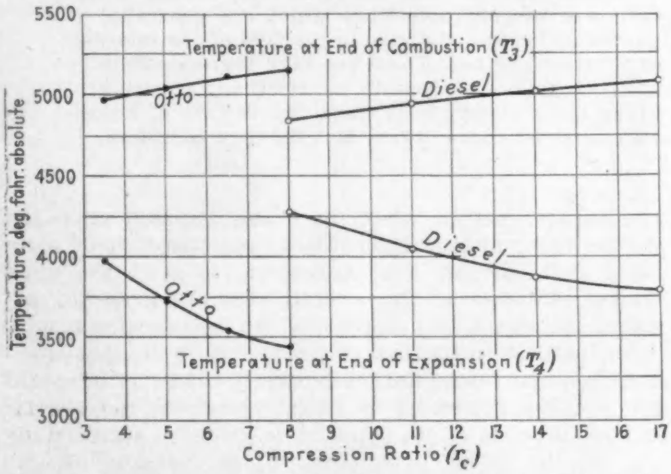


Fig. 1—Variation of Combustion and Exhaust Temperature with Compression Ratio

It Is Evident That Increasing the Compression Ratio from 4 to 8 Increases the Combustion Temperature for the Otto Cycle about 170 Deg. Fahr. While It Lowers the Exhaust Temperature about 530 Deg. Likewise, Increasing the Compression Ratio of a Diesel Cycle from 8 to 17 Increases the Combustion Temperature 240 Deg. Fahr. and Lowers the Exhaust Temperature 485 Deg.

When the compression ratio is increased, the expansion ratio is also increased, so that the question whether the improved thermal efficiency results from higher compression or more complete expansion is purely academic. We simply decrease the clearance space into which the gas is packed just before combustion and, by so doing, convert more energy of the combustible mixture into useful work. The significance of the distinction, however, lies in the fact that, out of the great mass of information which has been accumulated during the last few years in an effort to solve the problem of engine knock, only one item seems to be more or less universally agreed upon; namely, that increasing the compression increases the tendency to knock.

While the compression ratio of automobile engines has been increased gradually as a result of careful study of combustion-chamber design and the development of special fuels, engine knock is still the limiting factor in preventing a much greater increase in compression ratio and a corresponding improvement in engine efficiency. But if the respective rôles of compression ratio and expansion ratio are clearly appreciated, is it not possible to devise some means of increasing the expansion without at the same time increasing the compression? Numerous variable-stroke engines have been developed from time to time and, if engine efficiency becomes of greater importance, it seems probable that some such device can be developed that would make possible a considerable increase in the expansion ratio of the engine while keeping the compression ratio within certain specified limits. This question of the influence of compression ratio on engine efficiency has been mentioned merely because it is typical of the problems which can be investigated by means of a complete and accurate method of theoretical analysis.

Is High Diesel Efficiency Inherent?

The Diesel engine and high thermal-efficiency have been associated so long that Diesel efficiencies of 35 to 40 per cent are now accepted without comment. It may, however, be worthwhile to inquire whether this high efficiency is an inherent characteristic of the cycle itself or is merely the result of a combination of factors which are themselves common to all internal-combustion-engine cycles.

Curves in Fig. 2 show the variation of the ideal efficiencies for the Diesel and the Otto cycles when the compression ratio changes from 4 to 16 and the air supplied for combustion changes from 100 to 300 per cent of the theoretical amount necessary for complete combustion. Diesel efficiencies are indicated by the dash lines and Otto efficiencies by the solid lines, while the air-standard efficiency for each compression ratio is found to lie along the highest curve. These air-standard values are thus seen to have very little meaning, since they give no indication of the effects of mixture ratio upon efficiency. They are, however, the upper limiting values approached by the ideal thermal-efficiencies as the air-fuel ratio is increased.

It should be noted that, to compare the two cycles, efficiencies have been calculated for compression ratios and air-fuel ratios which are outside the normal operating values for one or the other of the cycles. Thus, the range of Otto-cycle compression-ratios has been extended up to 16 to 1 while the Diesel-cycle range has been extended down to 4 to 1. The air-fuel ratios for the Otto cycle include mixtures as lean as 45 lb. of air per pound of fuel and as rich as 14 lb. of air per pound of fuel. For the Diesel cycle the range of air-fuel ratios has been extended to include mixtures as rich as 15 lb. of air per pound of fuel. Evidently it is out of the question to operate either type of engine under such extreme conditions, owing to the difficulties of ignition and flame propagation. The validity of the calculated results thus found are, however, unaffected by these difficulties, since they depend only upon energy equations and equilibrium equations which are still valid in the regions of extrapolation; and some important conclusions can be drawn from the results.

First, it should be noted that, within the range of compression ratios under consideration, the Otto cycle is more efficient with 90 per cent of the theoretical air than is the Diesel cycle with 150 per cent of the theoretical air. An air-fuel ratio of 90 per cent is the one giving maximum power and corresponding to the

condition under which most automotive engines operate; therefore we see that, if it were possible to increase Otto-engine compression-ratios until they became comparable with the ratios commonly used in Diesel engines, the resulting Otto efficiencies, even with rich mixtures, probably would be as high as the average Diesel efficiency. Further, if the Otto-cycle engine could be operated with air-fuel ratios as high as 300 per cent of the theoretical air, its efficiencies would be considerably higher than those of the Diesel-cycle engine under the same operating conditions. It seems reasonable to conclude from these results that the high efficiency usually associated with Diesel engines is due primarily to the fact that they operate with high compression-ratios and high air-fuel ratios.

It was noted with considerable interest that one of the outstanding improvements in automotive-engine design exhibited at the 1928 Chicago Automobile Show was the application of a supercharger to a stock motor-car engine. The application, however, was rather unique in that, instead of compressing the air actually used for combustion, the air from the supercharger was admitted through an auxiliary valve in such a way that it formed a stratified layer just over the piston. This excess air probably does not enter into the combustion reaction to any great extent, but is nevertheless heated and expanded along with the products of combustion. This or some similar method of stratified charging might make it possible for Otto-cycle engines to be operated with compression ratios sufficiently high to give efficiencies about equal to the lower Diesel-cycle efficiencies. For, not only will stratification increase the Otto-cycle efficiency by the mere presence of excess air in the combustion space, but such air also should reduce knocking or detonating by absorbing energy during the early stages of combustion, thus enabling the engine to operate satisfactorily with higher compression.

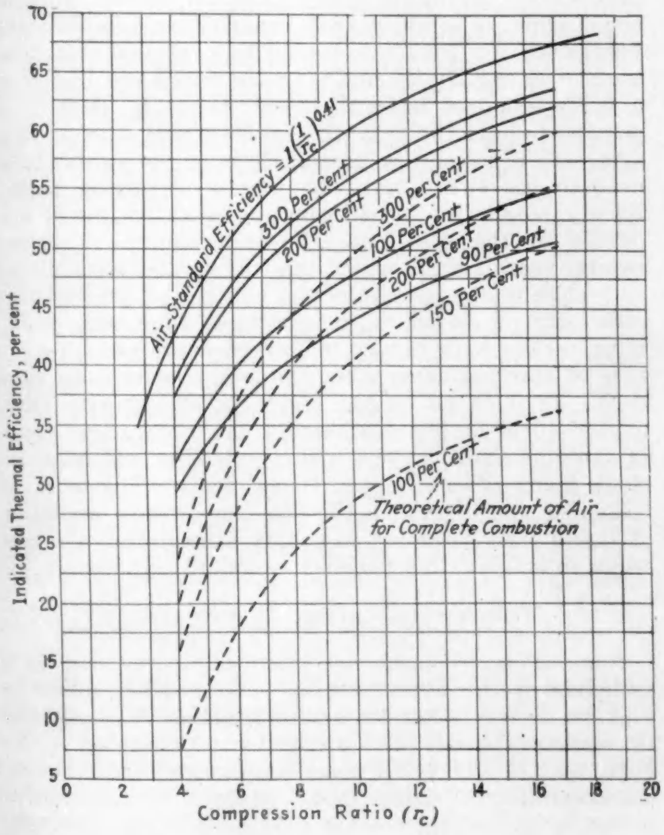


FIG. 2—IDEAL EFFICIENCIES FOR DIESEL AND OTTO-CYCLE ENGINES

The Effects of Variation in Compression Ratio and in Air-Fuel Ratio Are Shown. Diesel-Engine Efficiencies Are Indicated by Dash Lines and Otto-Engine Efficiencies by Solid Lines. Air-Standard Efficiency for Each Compression Ratio Is Found To Lie Along the Highest Curve

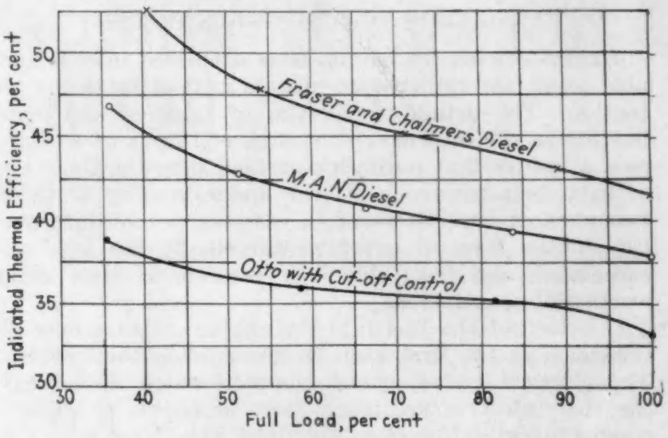


FIG. 3—VARIATION OF EFFICIENCY WITH LOAD

The Curves Indicate That, If Variable Cut-Off Control Could Be Applied to Engines Operating on the Otto Cycle, the Same Increase in Efficiency with Decreasing Load Could Be Expected. The Two Upper Curves Show the Variation of Thermal Efficiency with Changes in Load for Two Diesel Engines; the Lower Curve Is That Calculated for an Otto-Cycle Engine Having a 5-to-1 Compression-Ratio

The relatively higher part-load efficiencies of engines operating on the Diesel cycle, in comparison with their full-load efficiencies, is another characteristic which deserves consideration. The power output of the Diesel engine is controlled by changing the point at which the fuel-injection valve closes. This method of load control is very analogous to varying the point of cut-off in a steam-engine and the results in each case are the same; namely, by starting expansion earlier in the stroke at light loads the working medium is expanded to a lower pressure and temperature, thereby increasing the thermal efficiency as the load decreases.

Curves in Fig. 3 indicate that, if variable cut-off control could be applied to engines operating on the Otto cycle, the same increase in efficiency with decreasing loads could be expected. The two upper curves show the variation of thermal efficiency with changes in load for two well-known Diesel engines, while the lower curve is that calculated for an Otto engine with a 5-to-1 compression-ratio. The similarity in form of the Diesel and the Otto curves indicates that the advantage of high part-load efficiency depends, not on inherent characteristics of the Diesel cycle, but rather upon the method of load control. It is true that the method of fuel induction in the Diesel engine is particularly adapted to cut-off control, whereas the use of such control in the Otto engine offers not a few practical difficulties. In spite of this objection, the fact remains that, if high part-load efficiency is of first importance, Otto-cycle engines doubtless could be made to compare very favorably with Diesel engines in this respect.

Analysis of the Combustion Process

Engine efficiencies having been discussed in considerable detail, the combustion process next attracts our attention. The actual mechanism of ignition and combustion in the internal-combustion engine is of so complex a nature that purely theoretical investigations are of little help toward a clearer understanding of these two phenomena. However, a vast amount of information in the form of experimental results has been accumulated, and from this it is possible to draw some worthwhile conclusions.

Injection of the fuel into the engine cylinder may be regarded as the first step in the combustion process. The physical and chemical changes which accompany the fuel injection are much more amenable to experimental investigation than are those associated with the actual burning of the fuel. Thus the topic of fuel injection is not only the logical starting place for a discussion of Diesel-engine combustion, but it is also the one most likely to lead to fruitful results.

It has always been a more or less tacit assumption that, before proper burning could take place in any internal-combustion engine, the fuel had to be vaporized; but certain experimental investigations raise a question about the correctness of this assumption. Dr. Frank Sass has reviewed the more important of these investigations in a recent article entitled Modern Theories of Ignition and Combustion in Diesel Engines[8]. This survey contains so much interesting information relative to the problem of fuel vaporization and decomposition in the Diesel engine that the following brief summary is given here:

Diesel-Engine-Combustion Theories

Most Diesel fuels are vaporized at temperatures between 400 and 600 deg. fahr., when heated at atmospheric pressure. Early in the study of such fuels it was discovered that, upon the application of only a slight amount of heat, gas oils were given off, and a rather elaborate theory of combustion was evolved based upon assumption of gasification or decomposition of the complex Diesel fuels. In fact, fuels were compared on the basis of their so-called "hydrogen number." This number was defined as the ratio of the number of hydrogen molecules to the number of carbon molecules, the idea being that the hydrogen, separating from the fuel at rather low temperatures, is ignited by coming into contact with the heated air in the cylinder and in turn ignites the remainder of the fuel.

A comparison of liquid fuels shows, however, that some of the best Diesel fuels are more difficult to decompose or gasify in the manner described than are other similar fuels which burn very poorly in Diesel engines. Thus it has been found that coal-tar oil gives off a much greater quantity of oil gas, particularly hydrogen, than does paraffin oil under the same conditions of temperature and pressure. The former is a poorly burning Diesel fuel, while the latter burns very easily and completely.

It is next of interest to compare the ignition temperatures of the liquid fuel and its oil gases for several different Diesel fuels. The first result of such a comparison is the discovery that the oil gases are ignited at temperatures ranging from 400 to 600 deg. fahr. above the ignition temperature of the liquid fuel from which they are derived. It is found also that the ignition point of the oil gas is approximately independent of the fuel from which it is formed. Thus the ignition temperature at atmospheric pressure and in a stream of oxygen of the oil gases from fuels differing greatly in their behavior in Diesel engines varies by only 140 deg. fahr., while the ignition point of the liquid fuels themselves varies by more than 400 deg. fahr. Further, this variation in the ignition temperature of the liquid fuels corresponds very well with the degree of difficulty encountered in burning them in the Diesel engine, the less suitable fuels having the higher ignition-temperatures.

These facts certainly furnish rather conclusive proof of the fallacy of assuming that the liquid fuels must be decomposed into oil gases before ignition can occur.

Even more convincing evidence of the same nature is furnished by tests made on a hot-bulb semi-Diesel engine. These tests show that, at part loads, the temperature of the hot-spot may fall as low as 500 deg. fahr. without failure of ignition. If combustion depended upon ignition of the oil gases formed from the fuel, such ignition failure would occur whenever the hot-spot temperature drops below 750 deg. fahr.

Can Otto Engine Burn Atomized Fuel?

The time available for vaporizing the fuel, the period between the beginning of injection and the beginning of combustion, is so short that vaporization is practically precluded. We thus are forced to conclude that combustion in the Diesel engine occurs while the fuel is in a finely atomized but still liquid state. If, then, it is possible to burn the heavy Diesel fuels without vaporization, may it not also be possible to burn the lighter fuels used in the Otto engine by merely atomizing them? Such a possibility is not wholly speculative, as is evidenced by the Aseltine carburetion system developed several years ago, in which the fuel nozzles were placed very close to the inlet valves. A nozzle was provided for each pair of cylinders. The system gave very promising results with regard to fuel economy as well as to ease of starting, even when the less volatile fuels were used. If it is no longer necessary to vaporize Otto-engine fuels before combustion can occur, the range of possible fuels is very much extended and may include many of the lighter Diesel fuels. The work of Callender and others on the low-temperature oxidation of liquid fuels promises to supply information of great value in solving this problem of liquid combustion.

Otto-Cycle-Engine Modification

None of my remarks are intended in any way as a criticism of the Diesel engine. The engine's place as a prime mover is far too well establshed to be affected by such theorizing. This discussion is presented in the hope that it will be of some assistance in furthering the possibility of using Diesel engines for automotive power by indicating certain modifications in the Otto-cycle engine which may give it characteristics similar to some of the highly desirable ones of the Diesel engine. For, whether combustion occurs at constant pressure or at constant volume is of little consequence so long as an engine burns the most available fuel with the highest possible economy, all factors of engine size and load demands being considered.

[8] See *Zeitschrift des Vereines Deutscher Ingenieure*, Sept. 10, 1927, vol. 71, No. 37.

Pistons and Oil-Trapping Rings for Maintaining an Oil Seal

By Harry M. Bramberry[1]

Indiana Section Paper — *Illustrated with* Drawings and Charts

PROVISION is made, in the piston and rings described by the author, for an adequate flow of heat from all parts of the piston-head to the cylinder-wall by means of adequate cross-section of aluminum alloy in the head and a tongue-and-groove type of piston-ring structure which provides a greater amount of surface than is usual for heat transfer. A labyrinth oil-seal is provided which aids heat transference and prevents leakage past the piston-rings, and the heat transfer is said to be such that the heat does not destroy the oil seal between the piston and the ring.

Charts are included that show the effects in reduced temperatures, oil consumption and gas leakage with the construction described.

Attention is given also to a skirt construction most suitable to use with the piston-head and rings described.

SEVERAL years ago the Tungtite type of piston and piston-ring underwent extensive research at the City of Washington by the Navy Department at both the aeronautic engine laboratories and the Bureau of Standards. The results of this development interested H. L. Horning, of the Waukesha Motor Co., who also conducted extensive investigation and development. The work at Waukesha contributed more to this development than any previous work, because Mr. Horning recognized and developed the salient features of the idea. This work extended over most of two years, and was done in connection with relatively low-speed, heavy-duty engines, having higher compression than was then common.

In 1925 the Chrysler Corporation became interested in this type of ring, which it has since adopted. Credit is due to its engineering department for the use of its laboratory equipment and its assistance in acquiring part of the information contained in this paper.

Improvement in plain compression rings of good manufacture during the last several years has been confined to manufacturing processes, resulting in only slightly better performance. The modern engine requires drastic improvement in piston and piston-ring design to reach its highest efficiency. Speed and compression have increased to a point where the rectangular ring and groove structure and the thin piston-head fail to function satisfactorily, mainly because of high pressures, excessive temperatures and inadequate lubrication. Following are some of the requirements that must be met:

Control of Piston-Head Temperature.—It is desirable that the maximum operating temperatures shall not exceed 375 deg. fahr., to assure adequate lubrication of rings and grooves and satisfactorily control the mechanical distortion of the piston-skirt, thereby preventing excessive friction. Adequate cross-section of metal is needed in the piston-head, designed to distribute the heat in direct paths to the entire piston-ring and groove structure. Aluminum alloy is best suited to meet this requirement. The ring-and-groove structure should be designed to trap oil and have adequate edge and face area to pass on to the cylinder the heat transferred to it from the piston-head.

Adequate Compression-Seal.—The ring structure must be so designed that the rings will follow the cylinder-wall and seal the piston and the ring grooves at all engine speeds and temperatures.

Satisfactory Oil-Control.—From 800 to 1500 miles per gal. at 50 m.p.h. is regarded as satisfactory oil-consumption for the modern six-cylinder passenger-car engine. Eight hundred miles per gallon must be exceeded to maintain clean oil in the sump. If oil passes the rings faster than it is consumed, some of it returns to the crankcase and carries with it impurities from the combustion chamber.

Long Life.—These parts must function as intended and give satisfactory performance without requiring the usual replacement. The life of every moving part in the crankcase is influenced to a considerable extent by the effect of the pistons and rings on lubricating conditions.

Limitations of Conventional Design

The head of the piston illustrated in Fig. 1 operates at approximately 500 deg. fahr., which causes it to expand excessively, resulting in mechanical distortion and excessive friction of the skirt; destroys lubrication of the rings and grooves; decomposes the lubricant on the under side of the piston-head; and interferes to a considerable extent with combustion, especially in a high-compression engine.

The rings in Fig. 1 fail to follow the cylinder-wall at high piston-speeds, thus allowing blow-by. The effect of blow-by is more serious than the direct results of heat that have been enumerated. Explosion pressures enter behind the rings, increasing the radial pressure and causing excessive wear on rings, grooves, pistons and cylinder-walls. Increased blow-by and short life of these parts result. The ability of a structure of this design to transfer heat to the jacket water is extremely limited, because of inadequate edge and face area and the lack of sufficient oil in the grooves at high speeds.

Adding more metal to the cross-section of this piston-

[1] Engineer, General Piston Ring Co., now The Perfect Circle Co., Detroit.

head would result in little or no advantage, because of the inability of the rings to transfer to the jacket water any increased quantity of heat transferred to them by the additional metal in the head.

If the oil-trapping, heat-transferring ring-structure shown in Fig. 2 were combined with the cross-section of head in Fig. 1, a slight drop in temperature would result; and the effective sealing and oil-trapping advantages of this structure would be evident, as well as lower radial wall-pressure, better oil control, and longer life of the rings, grooves and cylinder-walls. But to gain the full advantages of either the rings or the head section, they should be combined.

Providing for Heat Transfer

The combination of piston-head and ring shown in Fig. 2 satisfactorily meets the requirements for modern engines, because of sufficient metal suitably placed in the piston-head, in combination with a ring-and-groove design that makes use of the oil as a seal and aids in heat transference to the jacket water. The quantity and the distribution of metal in the head are proportioned for each diameter to distribute to the ring zone all the heat absorbed from the burning gases, natural losses excepted; the rings are so designed that there is approximately as much edge area of the plain sealing surfaces as there is piston-head area; and the ring-face area used is at least 68 per cent of the piston-head area. The ring-face widths, as well as the wall depths, are adjusted in proportion for different diameters. In this way the piston-head temperature can be predetermined in a well-jacketed engine.

The temperature at which this combination operates is low enough to prevent cracking of the lubricant in the ring grooves and on the under side of the piston-head. This results in satisfactory lubrication.

Tungtite piston packing consists of two pairs of L-shaped concentric piston-rings, each pair placed in one wide groove in the piston. In the middle of the wide groove is a projecting rib, dividing the wide groove into two narrow grooves. A clearance A of 0.005 to 0.010 in. is provided between the thin flanges B on the rings. These flanges project over the rib, almost closing the space between the top of the rib and the cylinder-wall. Thus is formed a labyrinth joint between the piston and the rings. Oil is scraped from the cylinder-wall at openings A and passes to the plain side C of the rings, where it acts to lubricate sufficiently and to seal. This method of lubrication makes possible the use of high compression and high speed with satisfaction, because the rings follow the cylinder-walls, although the radial pressure of the rings is between 15 and 20 per cent lower than that of the rings shown in Fig. 1.

Each groove has three spaces, D, which are made as small as practicable for mechanical clearance, such small clearances being satisfactory because of the low expansion of the piston-head. These spaces also are filled with oil, through the openings A; therefore the entire ring structure operates under a partial hydraulic seal under all conditions. The trapped oil thus results in an almost perfect compression-seal, and prevents the explosion pressures from acting so readily back of the rings, permitting the rings to follow the cylinder-walls.

If the ring combination shown in Fig. 2 were assembled in grooves of insufficient spacing, the two flanges B would come into contact with each other under explosion pressure and prevent the rings from functioning. Insufficient lubrication of the surfaces C, because of the openings A being closed, would allow the downward pressure from the explosion forces to hold the ring flanges B in contact with each other and relieve the pressure on surfaces C, causing high unit pressures at B and E. The radial pressure of the rings would then be insufficient to overcome the friction due to the downward explosion pressure, and the result would be severe ring-snap and blow-by. With such a condition, the performance would approximate that of the structure shown in Fig. 1. The openings A are positively necessary for satisfactory performance, because each ring must function independently.

The poorer results obtained with the design shown in Fig. 1 are due to high unit pressures and lack of lubrication on the surfaces C, together with the action of explosion pressure back of the rings, which increases the radial pressure and blows out any oil that may have accumulated in the groove during low-speed operation. Once this oil has been blown out, it cannot be replaced

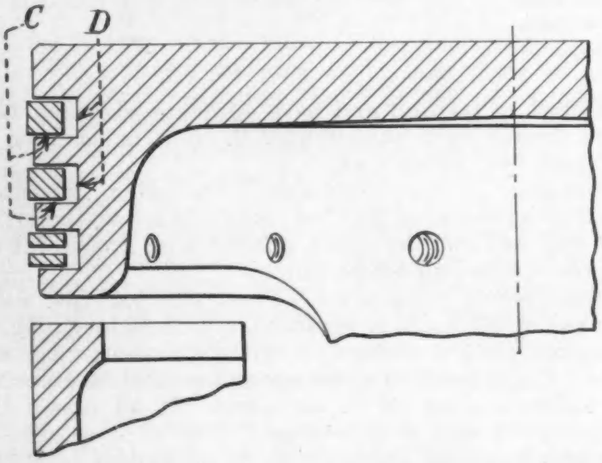


Fig. 1—A Conventional Piston-Head with Rectangular Rings

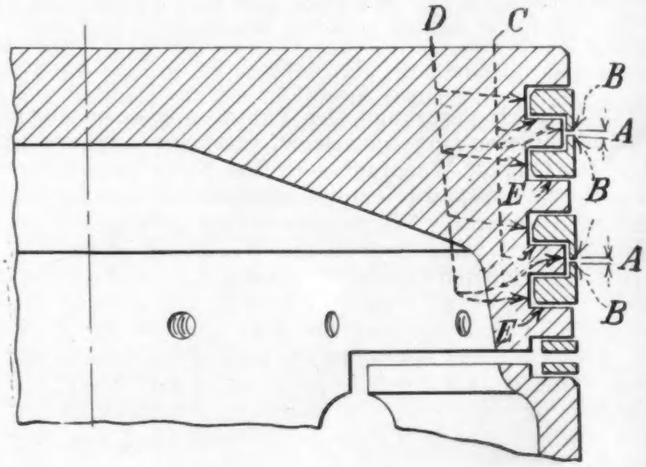


Fig. 2—Tungtite Oil-Trapping Rings and Piston-Head
The Head is Proportioned to Transfer the Heat to the Ring Zone. The Compression Rings Are Mounted in Pairs, with Clearance Between Them at A. Oil Is Trapped in the Groove on All Sides of the Ring, Aiding in the Heat Transfer and Preventing Wear and Blow-By

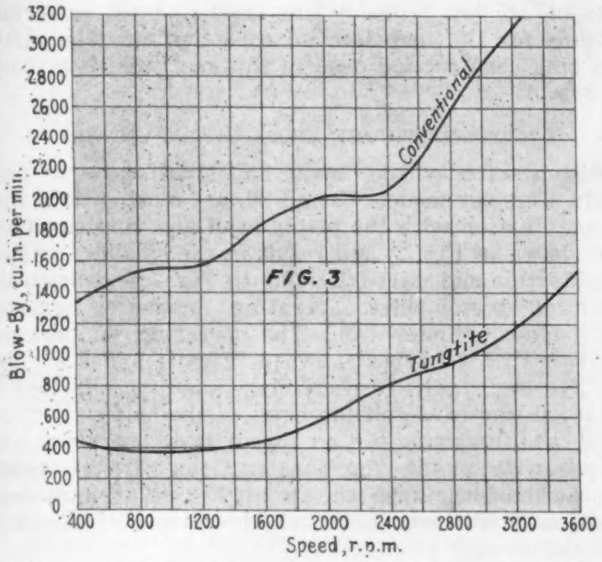


FIG. 3—COMPARATIVE BLOW-BY CURVES WITH PISTON-RING CONSTRUCTIONS AS IN FIGS. 1 AND 2

until the engine speed is reduced and the vacuum from the suction stroke is sufficient to cause the cavities to refill. Comparative curves showing the blow-by, or leakage, of the two designs are shown in Fig. 3.

OIL CONSUMPTION AND RADIAL PRESSURE

Oil consumption is an important problem, and is difficult to solve because of the minute oil-films to be dealt with. Oil consumption can be and is affected by almost any change in piston-rings, ring grooves, piston design, clearances, cylinder distortion, machine finish, wear, oil pressure, temperature of lubricant, quantity of oil delivered to the cylinders, and the like. The type of oil-

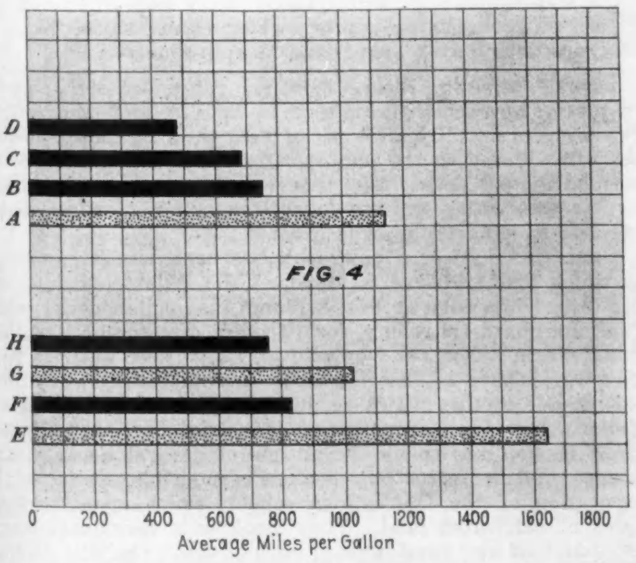


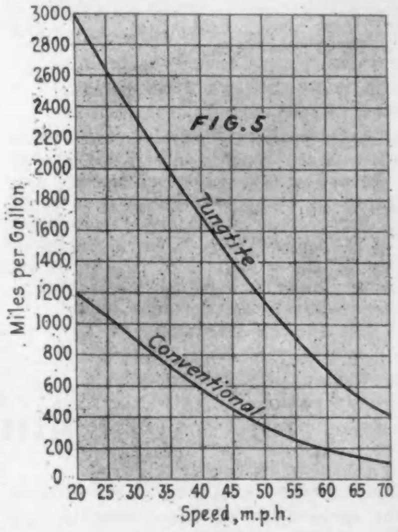
FIG. 4—EFFECT OF UNIFORM RADIAL-PRESSURE OF PISTON-RINGS ON OIL CONSUMPTION

A, *B*, *C* and *D* Represent Runs with a Fan-Brake, Each Run Lasting 5 Hr. at Full Load, with All Temperatures Constant and at a Speed Corresponding to 50 M.P.H. *E*, *F*, *G* and *H* Represent Road Runs. *E* and *F* Were 6650 Miles Each, and *G* and *H* Were 2777 Miles Each. *A*, *E* and *G* Represent Rings That Were Generated to Free Shape, While the Others Were of Conventional Form, Cast to Shape

regulating ring with the continuous lubricating groove and oil-draining slots has proved superior, and is used in combination with the compression rings as shown in Fig. 2.

Cylinder distortion is causing unnecessary problems in oil control and piston-skirt clearances. More work should be done to better this condition. Especially is this true in the present in-block cylinder castings.

It has been proved that differences in flexibility, radial pressure and cylinder contact of the face bearing-surface affects oil consumption more than anything else about compression or oil rings. Fig. 4 represents the results of a test of the effects on oil consumption of different radial pressures of the rings. Rings having the more nearly uniform radial pressure give the lowest oil consumption. The Tungtite construction shown in Fig. 2 was used, two pairs of 3¼-in.-diameter rings for the fan-brake runs and one pair of 3-in.-diameter rings



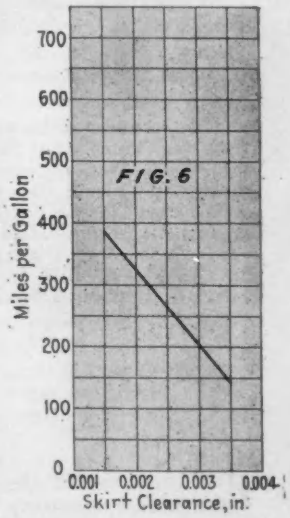


FIG. 5—COMPARISON OF OIL CONSUMPTION WITH RINGS OF DIFFERENT TYPES

FIG. 6—EFFECT OF SKIRT CLEARANCE ON OIL CONSUMPTION

This Test Was Made on a Fan-Brake at a Speed Corresponding to 50 M.P.H. The Skirt Clearance Was Changed Between Runs by Grinding. The Clearances Used Were 0.0015, 0.003 and 0.0035 in.

for the road runs. The rings of each size were identical in all of the usually measured dimensions, and no difference was apparent after the test. The difference in face contact or free shape can be measured only by laboratory equipment, so a special contour-gage was made to check the rings used in this test. Minute differences in the face contact of piston-rings affect the wiping action and radial pressures so little that it is hard to conceive how they could affect oil consumption as they do, yet when we consider that we are dealing with oil films 0.000001 in. or less in thickness, it is not hard to realize.

The oil consumption of a 3¼ x 5-in. high-compression modern engine, at various speeds and at road loads, using the two constructions shown in Figs. 1 and 2, is shown in Fig. 5. The difference in oil consumption is marked; also the effect of speed on consumption.

Another factor that affects oil consumption to a considerable extent is piston clearance. The piston needs to fill the cylinder completely without being tight enough to cause undue friction. Fig. 6 shows the effect on oil consumption of increasing the skirt clearance.

The greater clearance allows the ring faces to rock and to wear oval. This condition and the additional thickness of oil film probably are the two most important reasons for the increased oil consumption. The piston and ring construction used in this test was that shown in Fig. 1.

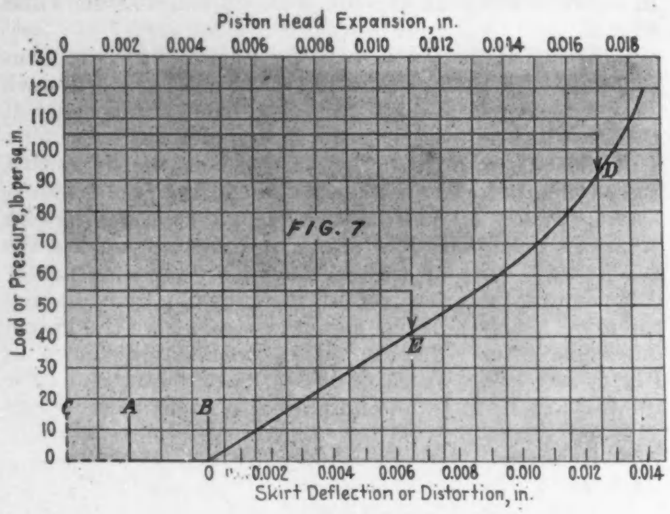


FIG. 7—CLEARANCE, EXPANSION AND DISTORTION OF PISTONS

A-B Represents the Clearance Between the Cylinder and the Piston at 70 Deg. Fahr. *A-C* Represents the Expansion of the Cylinder Between 70 Deg. and the Operating Temperature. *B-C* Is the Amount the Piston Can Expand Without Distortion. *D* and *E*, on the Curve, Read on the Upper Scale, Show the Piston-Head Expansion at Temperatures of 500 and 350 Deg. Fahr., Respectively. Corresponding Deflections of the Piston-Skirt Are Read on the Lower Scale, and Resulting Pressure Against the Cylinder-Wall Is Read on the Scale at the Left

Provision for the Cross-Head Function

Piston skirts of the "invar half-strut" type, as used in the Chrysler models 72 and 80, are most satisfactory in combination with the piston-head and ring construction shown in Fig. 2, and result in the smallest amount of distortion and skirt friction. In Fig. 7 are shown the resultant piston-skirt operating pressures exerted against the cylinder-wall. The operating temperature of pistons of the types shown in Figs. 1 and 2 are 500 and 350 deg. fahr., respectively. Load was applied to the lower end of the piston skirt of the half-strut type, parallel to the piston-pin, to approximate operating conditions with piston-ring constructions of both types. The head of the type shown in Fig. 2 expands less, therefore it distorts less at the lower end of the skirt and causes less friction.

Of the many tests of various types, Fig. 7 shows only one, of an invar full-strut design, which functions without the usual distortion and friction. In this design, both cross-head shoes are completely controlled thermally, and the piston-pin bosses are entirely disconnected from the skirt. The struts were designed to compensate fully for the differential of expansion between the head and the skirt. The ring and head construction shown in Fig. 2 was necessary for the operation of this skirt with small clearance.

The Agricultural Revolution

THE first use of the tractor was simply as a substitute for horses, drawing the same type of farm machinery, but now all farm machinery is being adapted to tractor power, with the result that the capacity of man-power is greatly increased.

Thomas D. Campbell, who as president of the Campbell Farming Corp. is directing operations on about 95,000 acres of land in Montana, writes in the *Magazine of Business:*

> Labor costs per acre on our job, at $6 a day for engine operators, are less than they were 30 years ago when the standard wage for "hired help" on the farm was $26 a month and board.
>
> We have developed large power units and hitches whereby we can plow an acre of land at a labor cost of 27 cents, seed it for about 7 cents labor cost, double-disk it for 10 cents an acre, and harvest and thresh it at a labor cost of 40 cents an acre.
>
> The present combine, at its reasonable cost, is the most outstanding development in agricultural machinery that has ever been accomplished. It has done more to reduce the cost of harvesting and threshing than any other method which has been developed up to this time.

Prof. M. L. Wilson, agricultural economist of the Montana Experiment Station, is quoted as follows:

> Three years ago there were few farmers anywhere in the world who produced wheat with less than 8 hr. of man-labor to the acre. Today many well-organized, efficiently operated tractor wheat-farms raise their crops with only 2 hr. of man-labor per acre.

Plows, harrows, disks, mowers, rakes, seeders, corn-planters, corn cultivators, potato-diggers and machinery for doing practically all kinds of field work by motor-power are now offered to the public. One man with a three-row corn-cultivator does three times the work formerly done by one man with a one-row cultivator, and in plowing, disking and mowing the gain is greater.

Upon this subject a new book has been issued recently, in which Prof. Edward S. Mead, of the Wharton School of Finance, University of Pennsylvania, has collaborated with Prof. Bernhard Ostrolenk, for 10 years director of the National Farm School, at Doylestown, Pa. These authors say that agriculture is entering upon an industrial revolution comparable to that which resulted from the substitution of steam power for man-power in industrial uses. Professor Mead is well known as the author of several books upon finance, and Professor Ostrolenk is responsible for the high reputation of the Doylestown school, which operates 800 acres of cultivated land. Their book is a very intelligent discussion of new conditions in agriculture. The title of the book is Harvey Baum—A Study of the Agricultural Revolution, and publication is by the Press of the University of Pennsylvania.—National City Bank of New York.

Front-Wheel Drives

Supplemental Discussion of Herbert Chase Semi-Annual Meeting Paper[1]

AFTER listing the advantages and disadvantages of front-wheel drive the author says that, although most American engineers who have given him their opinions seem to believe that the advantages of front-wheel drive are outweighed by its disadvantages, he has grounds for venturing the opinion that this form of drive is likely to have extensive use in this Country within the next few years. He bases this view more upon commercial than upon strictly engineering considerations; but the latter are not lacking altogether, as is evident from his subsequent analysis.

The advantages and the disadvantages are specifically and separately discussed, existing designs of front-wheel drive being divided into three classes. Numerous illustrations of the different types of front-wheel-drive vehicle are presented, and their most important features are enumerated and explained.

In conclusion the author says that, although there is good ground for the view that the advantages outweigh the disadvantages, it does not follow as a necessary corollary that front-drive cars will become the popular type or that they will be adopted soon by many manufacturers. Several companies are, however, greatly interested. Basically, nearly all American cars are very much alike in mechanical design and have undergone practically no major changes since the introduction of four-wheel brakes. We are about due for some radical changes in design, and it is not unlikely that one of these will be the front-wheel drive.

One of the discussers makes the point that, in the last 500-mile race, the troubles experienced with the front-wheel-drive racing cars could not be charged to the front-wheel drive itself. Another cites tests which disproved the claim that less power is required to propel a car by the front wheels than by the rear wheels. It is stated by another speaker that the failures of the supercharger drive-gears in the 500-mile race were mostly on cars having front-wheel drives. He says also that it is observable on the speedway that the front-wheel-drive cars spin their wheels much more than do the rear-wheel-drive cars at the same speed.

It is mentioned that front-wheel-drive cars follow the front wheels and have less tendency to skid on turns provided the driver has the courage to keep his foot on the throttle, but that this is a dangerous procedure. It is brought out also that the arrangements of independent wheel-springing and the reduction of unsprung weight can be applied equally well to front-wheel and to rear-wheel drives.

In conclusion, the author states the answers he received to the question: "What other major improvements do you consider more promising than front-wheel drives?"

HINSDALE SMITH[2]:—In addition to the 18 advantages of front-wheel drive listed in Mr. Chase's paper, I call attention to the ease with which the wheelbase can be changed; because the frame can be made straight and the points of attachment of the rear springs can be altered readily. These straight frames can be made lighter, and therefore should be considered cheaper because offsetting operations are avoided; also, they can be braced more effectively as no rear-axle-bridge clearance is necessary, with its consequent interference. Further, since the sills of the body also are straight, this effects another saving.

A very considerable saving of weight will be made in combining worm drive with speed-change gears all in one case. This case can be made of aluminum and need be but little larger than the standard gearbox, thus saving much of the weight of the rear banjo and resulting in a distinct saving of cost. The weight of the propeller-shaft and the torque-arm or tube also are saved.

Worm drive offers several advantages. It disposes of Mr. Chase's disadvantage No. 9, a noisy drive. By giving the front driving-axles a slight camber, the road clearance can be increased over that of the rear-wheel drive, thus substituting an advantage for disadvantage No. 8. The overhead worm raises the engine several inches higher than is the case with the bevel drive, thus giving plenty of room for an engine oil-pan having full depth.

I would leave the brakes on the front wheels, for the following reasons: The same size of drums and fittings can be used on both front and rear wheels, thus reducing the number of different parts per car. Relining of brakes might be a difficult operation if the brakes are mounted inside the frame. In any event it would be considerably more difficult than when the brakes are at the hub. Further, the propeller-shafts could be made much longer, being carried in close to the differential gears. This would reduce the angularity of the drive-shafts and give lessened universal-joint and slip-joint action. Non-revolving metallic covers could be fitted and would prevent the flying of any grease, which is often thrown from rapidly revolving universal-joints.

Low-Hung Body To Provide Comfort

In regard to Mr. Vincent's criticisms that "Cars with rear-wheel drive can be built so low that passengers when seated have their eyes as near the ground as when walking," and that, "there seems no advantage in further lowering of the body," is it not true, assuming that a body of this height answers the present requirements,

[1] Oral discussion at the meeting was printed with the paper in the September, 1928, issue of THE JOURNAL, p. 270. The written discussion printed herewith is supplementary. Mr. Chase is engineer for the Erickson Co., Inc., New York City, and a member of the Society. The abstract of the paper and previous discussion is reprinted above for convenience of the reader.

[2] M.S.A.E.—Experimental engineer, Springfield, Mass.

that in keeping this height of seat from the ground bodies would be much more comfortable if the floors were dropped 2 to 3 in.? This in many cases would make elderly or stout people more comfortable, and it would give greater legroom or allow a shorter wheelbase. It also would make it much easier to enter or leave the car than with the present low bodies. The shortened body space required would offset the additional few inches required by the front-wheel driving-mechanism, mentioned as disadvantage No. 4 on Mr. Chase's list.

By combining worm drive and transmission, the distance from the dash to the front axle need be but a few inches more than on rear-drive cars, and that can be made up in decreased body length. A three or four-speed transmission can be used, the latter having an internal-gear silent speed.

Anyone who has observed the Latil front-driven municipal vehicles used by the City of Paris cannot fail to have been impressed by the enormous bodies permitted by this front-drive construction on rubbish-collecting and street-watering vehicles. The latter have tanks of nearly twice the capacity of those on rear-drive vehicles.

In regard to independent springing, often mentioned in connection with front-wheel drive, my experience is not wholly favorable. When turning corners at speed, centrifugal action tips both body and wheels so that the center of gravity is unfavorably displaced as compared with wheels carried on cross axles. In a small car I built, springs soft enough for comfortable riding were distinctly unpleasant when going around a curve. The Sizare car in France impressed me in the same way. A device that would come into action on curves to stiffen the springs would be very desirable. Independent springing has one advantage that I never have seen mentioned; that is, that wider bodies can be used because the wheels are always parallel with the side of the body.

HERBERT CHASE:—Mr. Smith's interesting and pertinent discussion not only confirms many of the points brought out in my paper but indicates a careful study of certain points which are well worth stressing. I have been somewhat disappointed that many other members who have investigated front-wheel drives with considerable thoroughness have not given the Society the benefit of their observations and conclusions.

I cited simpler and less expensive frame-construction as among the advantages gained by front drive, having in mind much the same items that Mr. Smith covers more specifically. Ease of changing wheelbase is an undoubted advantage from the viewpoint of a manufacturer, especially a manufacturer of trucks who wishes to provide for variation in this respect; but this advantage does not apply, of course, to a single specific design of given length.

In respect to the degree of quietness possible with front-wheel drive I said, "I should expect the greater noise with the uninsulated front-drive unless a worm drive is employed. . . ." The advantages of the worm drive which Mr. Smith points out are, indeed, well worth consideration.

Most Desirable Brake Location

As to placing brakes on the front wheels instead of mounting them on or close to the differential housing, there is room for difference of opinion; but, for reasons given in the paper, I believe the latter arrangement presents the greater advantage, especially because the unsprung weight is decidedly less, the operating mechanism is far simpler and the springs are relieved from all brake reaction. The increased angularity occasioned by placing brake-drums between the differential and the driveshafts and shortening the latter 3 in. or less is negligible, for in no case is the total angle, even under greatest spring deflection, more than a fraction of the maximum steering-angle through which the universals must be designed to function, and a good design will reduce the angle under normal average spring deflection to a few degrees at most. The difference in accessibility between mounting the brakes on the chassis or on the wheels need be very slight. In either case the brake-shoes or brake-band would need to be removed from the drum for relining, and this can be made a very easy operation to perform whether the drum is on the wheel or a foot or two nearer the center line of the chassis. In one case the wheels and, in the other case, a cover fully as easy to handle would be taken off.

No apparent reason exists why most if not all the same parts used in rear brakes cannot be used also on front brakes even though the latter be mounted adjacent to the differential. The very desirable interchangeability seems to me to be possible in either case.

Body Length in Reference to Wheelbase

I am inclined to agree with most of Mr. Smith's comments regarding the passenger-car body and its length in reference to wheelbase, but I am not fully convinced that it is not possible with careful design to avoid any material increase in the distance from the dash to the front axle when changing from rear to front drive. To shorten the body presents certain disadvantages, even though they would be mitigated, as Mr. Smith indicates, by lowering the floor. It is far better to keep the full length, if possible, and perhaps to lower the floor in addition.

One of the greatest advantages of the front drive is that it gives the automobile-body designer a much freer hand than he ever has enjoyed. Many of the limitations imposed up to the present disappear; this is a consideration of prime importance now that there is so great a premium on original design and style in body work.

The unpleasant tendency of cars with independently sprung wheels to tilt when rounding a curve, mentioned by Mr. Smith and referred to by M. de Lavaud in his paper on Independently Sprung Front Wheels a Remedy for Shimmy[3], is a consideration demanding some study; but it probably will be overcome, if, as many expect, independent-wheel springing, with or without front drive, becomes popular.

[3] See THE JOURNAL, June, 1928, p. 623.

College Automotive-Research Activities

INVESTIGATIONS included under the title above, when grouped according to subject matter, fall into seven divisions dealing with (*a*) engines; (*b*) petroleum and its products, embracing automotive fuels and their use, lubricants and lubrication; (*c*) chassis parts; (*d*) highways and the interrelation between them and automotive vehicles; (*e*) aeronautics; (*f*) metals and (*g*) miscellaneous. Groups (*a*) and (*b*) were covered in the October issue.

Investigation of Chassis Parts

Current interest in headlighting devices is shared by a number of college research groups. Among the projects reported in answer to the Research Department's questionnaire is one at the completely equipped optical laboratory of the Carnegie Institute of Technology, at Pittsburgh, where research with a view to perfecting the design of automobile headlight lenses and the interior lighting of closed cars and motorcoaches is being conducted under the direction of Prof. Harry S. Hower. Prof. Arthur H. Ford, of the electrical engineering department of the Iowa State University, Iowa City, Iowa, has also made a contribution in this field; and the electrical engineering department of the University of Michigan, Ann Arbor, Mich., anticipates study along this line.

Another project reported at the Iowa State University is a set of tests being conducted by Assistant Prof. M. L. Fox and T. H. Carmichael, at the College of Applied Science, on the rebound action of various types of spring suspension and the effect of snubbers and shock-absorbers. The tests are being made on an automobile chassis mounted on ball-bearing drums, geared by silent chain and change-speed transmission to a 100-hp. Sprague dynamometer. Seismographs have been specially designed and perfected for recording the motions of the body.

In this connection it is interesting to note the project at the Engineering Experiment Station of the State College of Washington, at Pullman, Wash., where the design, construction and application of a dynamometer testing-stand for complete automobiles is receiving the attention of A. C. Abell, and where H. V. Carpenter is making a similar study of new-type testing equipment for four-wheel brakes. The development of rapid and convenient testing apparatus is the objective in both cases.

The University of Michigan has turned the efforts of its mechanical engineering department toward the development of methods and test instruments for determining the effect upon the linear acceleration of a car of the moment of inertia of its rotating parts. Accelerometers of various types have been built, and three chronographs have been constructed. Work is now being done on perfecting another chronograph which promises exceptional accuracy. The personnel consists of one associate professor, two assistants, one mechanic, one group of graduate students varying in number from two to seven or eight, and another group of senior students varying in number from two to eight. Numerous data have been recorded but have not yet been released.

This is the second and concluding article containing information on the investigations going forward, or in some instances concluded, in colleges and universities. The first installment was published in the October, 1928, issue of THE JOURNAL, p. 405.

Frequently the Research Department is called upon to recommend to interested inquirers, laboratories or research workers that are competent to undertake the study of some specified problem. Often, too, failing to find desired information in published technical literature, recourse must be had to first-hand sources for the results of research performed but not reported.

To meet these and other needs, the Research Department endeavors to maintain contact with research projects being carried on in colleges and universities.

The same personnel has been conducting a study of the operating characteristics of engines and transmission systems of typical trucks of various capacities. The rolling resistance of the running-gear and the wind resistance of the body have been determined by open-road tests. Some difficulties encountered in the road tests have delayed the work for a time but it will be resumed at the first opportunity. The equipment includes all necessary devices for measuring temperatures, fuel consumption, power, and so forth, with a unique apparatus for measuring the rolling resistance on the road.

A series of tests to determine a method for measuring tire-displacement resistance, and also the variations in the amount of this resistance due to inflation pressure, axle load, speed, and type of tire have been carried on at the North Carolina State College, at Raleigh, N. C. Interest along this line has also been shown in the department of applied mechanics, at the University of Kansas, Lawrence, Kan.

Studying Gear Noise and Strength

With the growing demand for noise elimination, increasing attention has been turned toward gear refinement. This interest is evidenced in the college projects. The University of Michigan has been giving special attention to the problem of noise in the gears and other parts for four years and plans to extend the program over another year at least. The department of physics, which has a well-equipped laboratory, is cooperating with the department of engineering research and the work is receiving the attention of four faculty members and several assistants, usually two to four senior students.

Progress reports on numerous tests of the strength of gear teeth have been submitted by the Massachusetts Institute of Technology, at Cambridge, Mass., to the American Society of Mechanical Engineers. A special testing machine has been developed for this work by the A.S.M.E. Special Research Committee on Gears, of which Wilfred Lewis, of Philadelphia, is chairman.

William H. Rasche, of the Virginia Polytechnic Institute, Blacksburg, Va., has been in charge of a project to determine the efficiency, strength and

durability of spur gears. The results of this investigation are printed in two parts: An Analysis of the Lewis-Webb Gear-Testing Machines, and The Design of a Frictionless Gear-Testing Machine.[1]

Varnish and lacquer testing and a study of the fundamental organic chemistry of drying-oil acids are under way at Lehigh University, in Bethlehem, Pa.

HIGHWAY RESEARCH PROJECTS

The State College of Washington submits a list of projects concerning highways and the interrelation between them and automotive vehicles, such as the relation of automobile design to the formation of rhythmic corrugations in highways, the results of which investigation are available in bulletin form[2]; and highway materials and the relation of road surfaces to tire wear, on which a progress report has been published.[3] A bulletin entitled Magnetic Nail-Picker for Highways[4] gives the results of an effort to develop suitable equipment for magnetically removing small iron objects from the highways.

Further tests in the field of highway research are reported by the North Carolina State College of Agriculture and Engineering, at which a special test vehicle with an electric drive superimposed upon the usual mechanical drive is used to determine the tractive resistance of different road surfaces.[5]

NUMEROUS AERONAUTIC PROJECTS

The Massachusetts Institute of Technology and the New York University are taking a prominent part in the field of airplane research. At the former, Prof. C. Fayette Taylor and three research associates are engaged in numerous projects of this nature, among which are listed an investigation of interference effects between airplane propellers and the airplane, including power absorbed, effect of radial engines, air-flow and so forth. Some material on this project has been published by the United States Army. Other projects listed are the finning of air-cooled cylinders with regard to the effect of fin size, shape, and pitch, under various conditions of temperature, air velocity, and turbulence; problems of supercharging; a comparison of performance and cooling characteristics of air-cooled and water-cooled cylinders, and a complete investigation of the effect of valve timing, valve lift, and compression ratio on volumetric efficiency and performance. Considerable special equipment is available at the Institute for these tests.

Research work is being carried on by Assistant Prof. Irwin H. Hamilton at the College of Engineering, New York University, in connection with an extremely light airplane engine of the two-cylinder, opposed-piston, two-cycle type.

MANY INVESTIGATIONS OF METALS

Automobile design and construction have reached a stage at which further improvement is dependent upon research into the detailed refinements that produce better performance. Competition in automobile production has also created a demand for an attractively finished body. Both these demands are reflected in the metal research work of the day.

The effect of heat-treatment on metals is a subject of research at several universities. The department of metallurgical engineering at Lehigh University is working on alloy steels; the mechanical engineering department of Michigan State College, East Lansing, Mich., is concerned with various phases of the process, such as salt baths used in heat-treating, the grain formation in low-carbon steel within critical ranges[6], heat of combination of the constituents of brass[7], and the causes of normal and abnormal steel work[8]. Numerous items of special equipment are available for these tests.

Prof. W. P. Wood, of the chemical engineering division of the University of Michigan, has worked along this line with a view to determining the relation of heat-treatment of various metals to their use in helical springs. Theodore S. Eckert, at the University of Maine, Orono, Me., reports work on Crystal Growth as Influenced by Hydrophilic Colloids. The practical mechanics department staff of Purdue University, at Lafayette, Ind., under the direction of Raymond H. Hobrock, is endeavoring to discover the effects upon the physical properties of nickel cast-irons occasioned by various heat-treatments. Iron cast in sand molds and in metal molds is included in the investigation.

The same personnel at Purdue University is at work on a process of nitriding special steels under pressure of nitriding gas, in an effort to discover the way in which the hardness, the hardness gradient, and the depth of penetration of the case vary with the pressure of the gas and with the time of treatment

STUDYING NON-FERROUS METALS

The Carnegie Institute reports study and tests on the properties of bearing metals, such as compressive strength and ductility, shock resistance, dry-friction hardness, shrinkage in pouring, behavior under failing lubrication, and the effect of temperature on their properties. Besides the usual equipment for testing the hardness and compressive strength of metals, the Institute has an impact tester for measuring resistance to shock, a dry-friction tester, and a specially built lubrication-failure test-machine on which the coefficient of friction, temperature rise, and wear of bearing metals in unit time are measured.

Associate Prof. E. D. Kinney, of the University of Kansas, is engaged in testing mid-continent zinc ores for the electrolytic process. The laboratory at the university is equipped with gas and oil-fired furnaces of various sizes, and the metallographic laboratory has a complete photomicrographic outfit.

A project on electrometric titration of manganese is reported by the chemistry and chemical engineering department of the University of Maine. Special testing equipment is available at the University of Michigan for investigators interested in the development of methods for measuring the properties of cores. The engineering department has worked on this project for a number of years and the results have been published by the American Foundrymen's Association.[9]

Gilbert E. Doan, assistant professor of metallurgy at Lehigh University, is conducting an inquiry into the nature of metallic solid solutions, and Maurice B. Levy, of the metallurgical engineering department, is attempting to determine more accurately than hitherto has been done the change points on the iron and steel equilibrium diagram. A specially designed furnace is being constructed for the making of these tests. Work in this field is reported also by F. C. Farnham at the School of Mines and Metallurgy, University of Missouri, Rollo, Mo., to determine the effect of small amounts of silicon on the magnetic-change point in mild steel. A later project is concerned with the measurement of the surface tension of solids. A compilation of useful data on the physical properties of alloys has been undertaken by C. H. Kent of the University of Navada, at Reno, Nev.

TESTING THE FATIGUE OF METALS

Tests to determine the factors that influence the fatigue strength of metals occupy a place in several college research programs. Prof. H. F. Moore, of the University of Illinois, Urbana, Ill., is especially interested in this subject, and the results of some of the tests

[1] See Virginia Polytechnic Institute Bulletin No. 3.

[2] See Engineering Bulletin State College of Washington No. 19.

[3] See Engineering Bulletin State College of Washington No. 16.

[4] See Engineering Bulletin State College of Washington No. 21.

[5] See Progress Report, Proceedings of the 6th Annual Meeting of the Highway Research Board, North Carolina, Dec. 2-5, 1926.

[6] See Engineering Experiment Station Bulletin No. 14, Michigan State College.

[7] See Engineering Experiment Station Bulletin No. 1, Michigan State College.

[8] See Engineering Experiment Station Bulletins Nos. 5 and 13.

[9] See *Transactions American Foundrymen's Association*, vol. 33, 1925, p. 72; vol. 34, 1926, p. 558; vol. 35, 1927, p. 158.

made in his laboratory have been published.[10]

The characteristics of different cast irons are being determined at the Engineering Experiment Station of the University of Wisconsin, Madison, Wis., by tension, compression, impact, cross-bending, hardness and fatigue tests. The State College of Washington has made extensive tests to determine the fatigue strength of electric welds for use in automobiles and other products. The project includes chemical analyses, photomicrographic studies, modified methods of welding, hardness tests, and so forth. Six fatigue-testing machines are employed. E. M. Sabbagh, of the electrical engineering department of Michigan State College, also is engaged in a project on electric welding.

The University of Maine undertook a microstructure study of metal fractures and the flow of metals when loaded beyond the elastic limit, to find the cause of failure of metals when subjected to various kinds of loads that obtain under severe operating conditions.

It is fitting to note in connection with metals the publication of a bulletin by the Massachusetts Institute of Technology on the Applications of X-Rays in the Automotive Industry, by G. L. Clark, R. H. Aborn and E. W. Brugmann.[11]

Research Projects on Plating

Under the heading of efforts to produce new and attractive finishes may be listed various projects on plating. The Michigan State College has spent a number of years studying chromium plating and as a result has developed a process that is commercially practicable.[12] Prof. W. P. Wood, of the University of Michigan, has likewise been engaged in research of this nature on the relation of chemical composition to corrosion rate and the effect of various protective coatings. He also has looked into the factors affecting corrosion, and articles on his findings have been published.[13] Other projects in Professor Wood's department cover the cleaning of metals for plating, the protective value of electrodeposited coatings, and the efficiency of polishing abrasives.

The University of Illinois undertook an investigation of enamels for sheet metals to determine the influence of composition upon certain physical properties, and the University of Maine is investigating the brightening effect of cadmium salts in nickel-plating. Sheets of copper and other metals of definite constant surface-area are being plated under standard commercial plating conditions in nickel-ammonium-sulfate solutions containing ammonium chloride and varying quantities of cadmium chloride.

Miscellaneous Projects

The department of physics at the University of Kansas has specially designed apparatus for studying the Jule-Thompson effect in gases. Some work was done on this subject and the findings were published in 1904 and 1905.

An investigation of carbon monoxide in the exhaust from gasoline engines and of the condition of the air in garages is being conducted at the University of Minnesota, in Minneapolis. The study is divided into two parts: first, an analysis of the exhaust from automobile engines under different operating conditions varying from an idling engine to full load; and second, an analysis of air samples from various garages under different conditions of ventilation, to determine the amount of carbon-monoxide gas present. With these data as a basis, it is hoped to work out an adequate ventilating system.

The Michigan State College has undertaken a statistical study of the costs of motorcoach transportation. The University of Michigan also is interested in this field, and research on the economic utilization of motorcoaches by street railways is being conducted by J. E. Bamborough, of the civil engineering department. The cost of automobile and truck transportation is a live project at the West Virginia University, Morgantown, W. Va., in cooperation with the State Highway Commission.

The State University of Iowa is investigating in its chemistry department the reproducibility and constancy of the electromotive force of the Weston standard cell and of other voltaic cells of the same type. A number of articles on this investigation have been published in the *Journal of the American Chemical Society* and the *Journal of the Optical Society of America* from 1924 to 1927.

Research is being conducted at the University of Illinois with a view to determining the effectiveness and limitations of the various mechanical methods of stress measurements.

Work has been done and is continuing at the Pennsylvania State College, State College, Pa., on the measurement of heat transmission through various materials. Investigations with a variety of materials and conditions have been carried on for 10 years, and bulletins have been published on various phases of the subject.

A considerable number of other projects have been outlined and apparatus for their conduct has been listed in answer to the Research Department's questionnaire. These projects have not been covered in this and the preceding report of college research activities. Of necessity the review has been confined to projects very closely related to the automotive field. However, a complete file of the information secured will be kept for reference.

[10] See Manual of Endurance of Metals Under Repeated Stress. By H. F. Moore. Published by the Engineering Foundation, 1927.

[11] See Serial No. 194, Chemical Engineering Department, Massachusetts Institute of Technology.

[12] See Chemistry Department Bulletin No. 7, Michigan State College.

[13] See *Chemical and Metallurgical Engineering*, April 30, 1923, p. 769; *Transactions American Society for Steel Treating*, July, 1925, p. 321.

Standardization Activities

Milling-Cutter Standards Proposed

Tentative Final Report Submitted by Committee for Approval or Constructive Comments

THE first step approaching a National basis toward the standardization of milling-cutters was taken early in 1925 by a somewhat limited conference of milling-cutter manufacturers and users in Washington. This resulted in the Department of Commerce simplified recommended-practice report based on the manufacturers' selling lists. In September, 1926, a conference by another group was held at the New Haven Machine Tool Exhibition at Yale University at which it was decided to carry the project further under the procedure of the American Engineering Standards Committee, looking toward the adoption of a definite American Standard for Milling-Cutters. Accordingly, a Technical Committee No. 5 on Milling-Cutters was organized under the Sectional Committee on the Standardization of Small Tools and Machine-Tool Elements, which is sponsored by the National Machine Tool Builders Association, the American Society of Mechanical Engineers and the Society of Automotive Engineers under the procedure of the American Engineering Standards Committee.

The 23 members of the Technical Committee were selected by the sponsors from among the principal milling-cutter manufacturers and users, including machine-tool manufacturers, of whom H. P. Harrison, of the H. H. Franklin Mfg. Co., and D. W. Ovaitt, of the Buick Motor Co., represent the Society's interests.

Report Very Carefully Drafted

It is believed that the accompanying report now proposed for approval is the result of careful consideration of all available data on current practice and requirements in the manufacture and use of milling-cutters. The results of the effective work conducted by the Buick Motor Co., under the direction of Mr. Ovaitt, on the investigation of the efficiencies of various tools and production operations has been an important factor in the preparation of this report.

Milling-cutters were classified on the basis of their use, for the purpose of formulating preliminary reports on cutters of the various types, several of the preliminary reports being drafted in May, 1927. The preliminary reports were withheld, however, for further consideration, with the exception of the report on Shell-End Mills, which was published in the June, 1927, issue of THE JOURNAL to elicit comments by the industry and distributed to the members of the Production Division of the S.A.E. Standards Committee for their study. The resulting proposed specification is shown in the accompanying Table No. 15.

In June, 1928, a preliminary report on Nomenclature for Milling-Cutters was drafted by Technical Committee No. 5. This was referred to the Production Division of the S.A.E. Standards Committee, and the final draft has not yet been issued by the Technical Committee.

The accompanying tables give only the diameter and thickness of cutters and the diameter of the hole. Work is now in progress on detail specifications for the keys and keyways, the first draft of which was printed on p. 321 of the March, 1928, issue of THE JOURNAL. This part of the specifications will be incorporated in the report later.

Procedure in Preparing a Standard

Standardization of milling-cutters is one of a number of projects for machine-tool standardization under the direction of the Sectional Committee on Standardization of Small

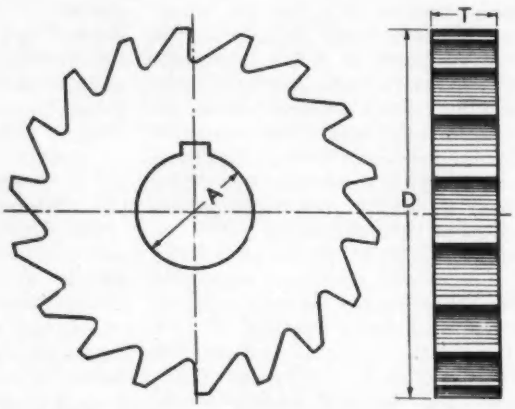


Table No. 1. Plain Milling Cutters (Light Duty)

Diameter of Cutter D			Width of Face T			Diameter of Hole A		
Nom.	Max.	Min.	Nom.	Max.	Min.	Nom.	Max.	Min.
2 ¼	2.265	2.235	½	.5150	.4850	⅞	.876	.875
2 ¼	2.265	2.235	1	1.0010	.9990	⅞	.876	.875
2 ½	2.515	2.485	3/16	.1885	.1865	1	1.001	1.000
2 ½	2.515	2.485	¼	.2510	.2490	1	1.001	1.000
2 ½	2.515	2.485	5/16	.3135	.3115	1	1.001	1.000
2 ½	2.515	2.485	⅜	.3760	.3740	1	1.001	1.000
2 ½	2.515	2.485	7/16	.4385	.4365	1	1.001	1.000
2 ½	2.515	2.485	½	.5010	.4990	1	1.001	1.000
2 ½	2.515	2.485	⅝	.6260	.6240	1	1.001	1.000
2 ½	2.515	2.485	¾	.7510	.7490	1	1.001	1.000
2 ½	2.515	2.485	1	1.0010	.9990	1	1.001	1.000
2 ½	2.515	2.485	1 ½	1.5100	1.5000	1	1.001	1.000
2 ½	2.515	2.485	2	2.0100	2.0000	1	1.001	1.000
2 ½	2.515	2.485	2 ½	2.5200	2.5000	1	1.001	1.000
2 ½	2.515	2.485	3	3.0200	3.0000	1	1.001	1.000
3	3.015	2.985	3/16	.1885	.1865	1	1.001	1.000
3	3.015	2.985	¼	.2510	.2490	1	1.001	1.000
3	3.015	2.985	5/16	.3135	.3115	1	1.001	1.000
3	3.015	2.985	⅜	.3760	.3740	1	1.001	1.000
3	3.015	2.985	⅜	.3760	.3740	1 ¼	1.251	1.250
3	3.015	2.985	7/16	.4385	.4365	1 ¼	1.251	1.250
3	3.015	2.985	½	.5010	.4990	1 ¼	1.251	1.250
3	3.015	2.985	⅝	.6260	.6240	1 ¼	1.251	1.250
3	3.015	2.985	¾	.7510	.7490	1 ¼	1.251	1.250
3	3.015	2.985	⅞	.8760	.8740	1 ¼	1.251	1.250
3	3.015	2.985	1	1.0010	.9990	1 ¼	1.251	1.250
3	3.015	2.985	1 ¼	1.2600	1.2500	1 ¼	1.251	1.250
3	3.015	2.985	1 ½	1.5100	1.5000	1 ¼	1.251	1.250
3	3.045	2.985	2	2.0100	2.0000	1 ¼	1.251	1.250
3	3.015	2.985	3	3.0200	3.0000	1 ¼	1.251	1.250
3	3.015	2.985	4	4.0200	4.0000	1 ¼	1.251	1.250
3	3.015	2.985	6	6.0200	6.0000	1 ¼	1.251	1.250
4	4.015	3.985	¼	.2510	.2490	1	1.001	1.000
4	4.015	3.985	¼	.2510	.2490	1 ¼	1.251	1.250
4	4.015	3.985	5/16	.3135	.3115	1 ¼	1.251	1.250
4	4.015	3.985	5/16	.3135	.3115	1	1.001	1.000
4	4.015	3.985	⅜	.3760	.3740	1 ¼	1.251	1.250
4	4.015	3.985	⅜	.3760	.3740	1	1.001	1.000
4	4.015	3.985	½	.5010	.4990	1 ¼	1.251	1.250
4	4.015	3.985	⅝	.6260	.6240	1 ¼	1.251	1.250
4	4.015	3.985	¾	.7510	.7490	1 ¼	1.251	1.250
4	4.015	3.985	1	1.0010	.9990	1 ¼	1.251	1.250
4	4.015	3.985	1 ½	1.5100	1.5000	1 ¼	1.251	1.250
4	4.015	3.985	2	2.0100	2.0000	1 ¼	1.251	1.250
4	4.015	2.985	3	3.0200	3.0000	1 ¼	1.251	1.250
4	4.015	3.985	4	4.0200	4.0000	1 ¼	1.251	1.250
4	4.015	3.985	6	6.0200	6.0000	1 ½	1.501	1.500

All dimensions given in inches.
Cutters of less than ¾-inch face have straight teeth.
Cutters of ¾-inch face and over have helical teeth.
Hand of spiral optional with cutter manufacturer.

Tools and Machine-Tool Elements. In general, the procedure is for a technical committee, such as Committee No. 5 on Milling-Cutters, to review all available data on this project as the basis for formulating a tentative report that is then submitted to the members of the Sectional Committee, to the sponsors and, through the latter, to the interested industries in general. A final report by a technical committee is then formulated on the basis of the results of circularizing the tentative report, and the final report is then submitted to the Sectional Committee for final approval by ballot. The Sectional Committee, upon approving the report, refers it to the sponsors for their approval, each in accordance with its own procedure.

In the case of the Society, the report will have to progress through the Production Division of the Standards Committee, the Standards Committee, the Council, a general business session of the Society, and final letter-ballot by the Society members, in the same manner as all regular S.A.E. standardization projects.

Upon approval by the sponsors, the report is finally submitted to the American Engineering Standards Committee for approval as to the adequateness of the procedure of the Sectional Committee and its Technical Committee and of the adequateness of industrial representation on these committees. Following this final approval, the report will be published by one of the sponsors and become generally available.

Tool Standardization Will Effect Economies

Although the automotive industries have generously supported standardization work for many years, the work has related primarily to the product. Only recently has active interest been taken in the standardization of tools and manufacturing equipment and of methods. The variety of types, sizes, and dimensions of milling-cutters and many other tools is amazing, and it is evident that standardization is one of the most effective means for effecting great economies to the industry in the manufacture, sale, stocking and using of cutting tools. These economies cannot be ex-

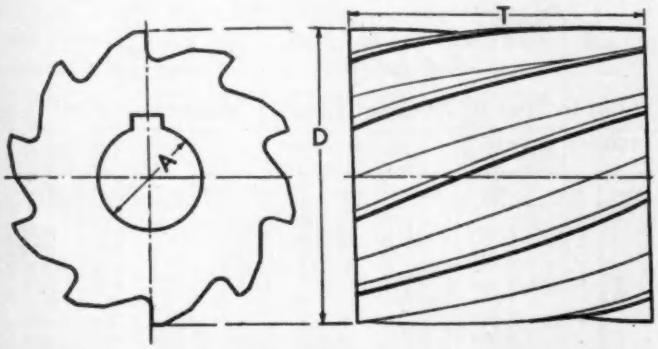


Table No. 2. Plain Milling Cutters (Heavy Duty)

Diameter of Cutter D			Width of Face T			Diameter of Hole A		
Nom.	Max.	Min.	Nom.	Max.	Min.	Nom.	Max.	Min.
2 ½	2.515	2.485	2	2 010	2.000	1	1.001	1.000
2 ½	2.515	2.485	2 ½	2.520	2.500	1	1.001	1.000
2 ½	2.515	2.485	3	3.020	3.000	1	1.001	1.000
2 ½	2.515	2.485	4	4.020	4.000	1	1.001	1.000
3	3.015	2.985	2	2.010	2.000	1 ¼	1.251	1.250
3	3.015	2.985	2 ½	2.520	2.500	1 ¼	1.251	1.250
3	3.015	2.985	3	3.020	3.000	1 ¼	1.251	1.250
3	3.015	2.985	4	4.020	4.000	1 ¼	1.251	1.250
4	4.015	3.985	2	2.010	2.000	1 ½	1.501	1.500
4	4.015	3.985	3	3.020	3.000	1 ½	1.501	1.500
4	4.015	3.985	4	4.020	4.000	1 ½	1.501	1.500
4	4.015	3.985	6	6.020	6.000	1 ½	1.501	1.500
4 ½	4.515	4.485	6	6.020	6.000	2	2.001	2.000
4 ½	4.515	4.485	12	12.020	12.000	2	2.001	2 000

All dimensions given in inches.
Heavy Duty Cutters have helical teeth.
Hand of spiral optional with cutter manufacturer.

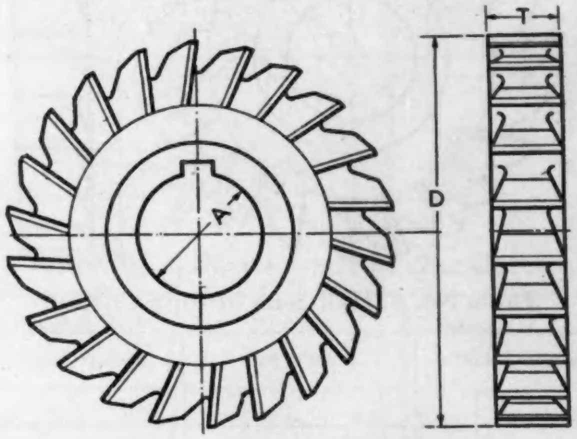


Table No. 3. Side Milling Cutters

Diameter of Cutter D			Width of Face T			Diameter of Hole A		
Nom.	Max.	Min.	Nom.	Max.	Min.	Nom.	Max.	Min.
2	2.015	1.985	3/16	.1885	.1865	½	.5010	.4990
2	2.015	1.985	3/16	.1885	.1865	⅝	.6260	.6240
2	2.015	1.985	¼	.2520	.2490	½	.5010	.4990
2	2.015	1.985	¼	.2520	.2490	⅝	.6260	.6240
2	2.015	1.985	⅜	.3770	.3740	½	.5010	.4990
2	2.015	1.985	⅜	.3770	.3740	⅝	.6260	.6240
2 ½	2.515	2.485	¼	.2520	.2490	⅞	.8765	.8735
2 ½	2.515	2.485	5/16	.3145	.3115	⅞	.8765	.8735
2 ½	2.515	2.485	⅜	.3770	.3740	⅞	.8765	.8735
2 ½	2.515	2.485	½	.5020	.4990	⅞	.8765	.8735
3	3.015	2.985	¼	.2520	.2490	1	1.001	1.000
3	3.015	2.985	5/16	.3145	.3115	1	1.001	1.000
3	3.015	2.985	⅜	.3770	.3740	1	1.001	1.000
3	3.015	2.985	7/16	.4395	.4365	1	1.001	1.000
3	3.015	2.985	½	.5020	.4990	1	1.001	1.000
4	4.015	3.985	¼	.2520	.2490	1	1.001	1.000
4	4.015	3.985	⅜	.3770	.3740	1	1.001	1.000
4	4.015	3.985	½	.5020	.4990	1	1.001	1.000
4	4.015	3.985	½	.5020	.4990	1 ¼	1.251	1.250
4	4.015	3.985	⅝	.6270	.6240	1	1.001	1.000
4	4.015	3.985	⅝	.6270	.6240	1 ¼	1.251	1.250
4	4.015	3.985	¾	.7520	.7490	1	1.001	1.000
4	4.015	3.985	¾	.7520	.7490	1 ¼	1.251	1.250
4	4.015	3.985	⅞	.8770	.8740	1	1.001	1.000
4	4.015	3.985	⅞	.8770	.8740	1 ¼	1.251	1.250
5	5.015	4.985	½	.5020	.4990	1	1.001	1.000
5	5.015	4.985	½	.5020	.4990	1 ¼	1.251	1.250
5	5.015	4.985	⅝	.6270	.6240	1	1.001	1.000
5	5.015	4.985	⅝	.6270	.6240	1 ¼	1.251	1.250
5	5.015	4.985	¾	.7520	.7490	1	1.001	1.000
5	5.015	4.985	¾	.7520	.7490	1 ¼	1.251	1.250
5	5.015	4.985	1	1.0020	.9990	1 ¼	1.251	1.250
6	6.015	5.985	½	.5020	.4990	1	1.001	1.000
6	6.015	5.985	½	.5020	.4990	1 ¼	1.251	1.250
6	6.016	5.985	¾	.7520	.7490	1	1.001	1.000
6	6.015	5.985	¾	.7520	.7490	1 ¼	1.251	1.250
6	6.015	5.985	1	1.0020	.9990	1 ¼	1.251	1.250
7	7.015	6.985	¾	.7520	.7490	1 ¼	1.251	1.250
7	7.015	6.985	1	1.0020	.9990	1 ¼	1.251	1.250
8	8.015	7.985	1	1.0020	.9990	1 ¼	1.251	1.250
8	8.015	7.985	1	1.0020	.9990	1 ¼	1.251	1.250

All dimensions given in inches.

pected to accrue over night but should become evident in a relatively short time, provided the industries to which they relate cooperate fully with the committees charged with the responsibility of formulating the standards, and, when the reports are finally approved, apply them in their particular branches of the industries. It should always be borne in mind that such standards must be kept within reasonable, practical limits of standardization and cannot be expected to cover all the requirements of use. Cases will arise in which special milling-cutters will be required for special purposes, and the fact that a standard has been generally adopted should not and does not prevent the customer from obtaining such special tools when required.

The accompanying report is submitted at this time for careful review by all the industries that will be affected, with the request that constructive criticisms or comments be referred to Technical Committee No. 5 through this So-

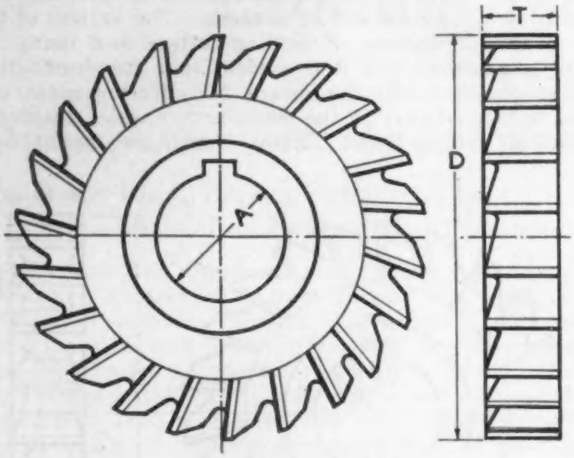


Table No. 4. Half Side Milling Cutter

Diameter of Cutter D			Width of Face T			Diameter of Hole A		
Nom.	Max.	Min.	Nom.	Max.	Min.	Nom.	Max.	Min.
4	4.015	3.985	¾	.752	.749	1 ¼	1.251	1.250
4	4.015	3.985	½	.502	.499	1 ¼	1.251	1.250
5	5.015	4.985	¾	.752	.749	1 ¼	1.251	1.250
6	6.015	5.985	¾	.752	.749	1 ¼	1.251	1.250
6	6.015	5.985	1	1.002	.999	1 ½	1.501	1.500
7	7.015	6.985	¾	.752	.749	1 ½	1.501	1.500
7	7.015	6.985	1	1.002	.999	1 ½	1.501	1.500
8	8.015	7.985	¾	.752	.749	1 ½	1.501	1.500
8	8.015	7.985	1	1.002	.999	1 ½	1.501	1.500
8	8.015	7.985	1 ¼	1.252	1.249	1 ½	1.501	1.500
9	9.015	8.985	1	1.002	.999	1 ½	1.501	1.500
9	9.015	8.985	1	1.002	.999	2	2.001	2.000
9	9.015	8.985	1 ¼	1.252	1.249	1 ½	1.501	1.500
9	9.015	8.985	1 ¼	1.252	1.249	2	2.001	2.000

All dimensions in inches.

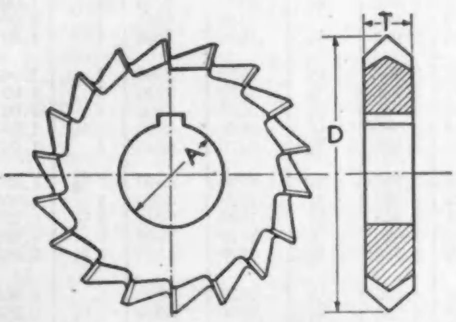


Table No. 9. Double Angle Milling Cutters

Diameter of Cutter D			Thickness T			Diameter of Hole A		
Nom.	Max.	Min.	Nom.	Max.	Min.	Nom.	Max.	Min.
2 ¾	2 765	2.735	½	.515	.485	1	1.001	1.000

All dimensions given in inches.
Double angle cutters will be furnished with an included angle of either 45, 60 or 90 degrees.
Tolerance for angle, plus or minus 10 minutes.

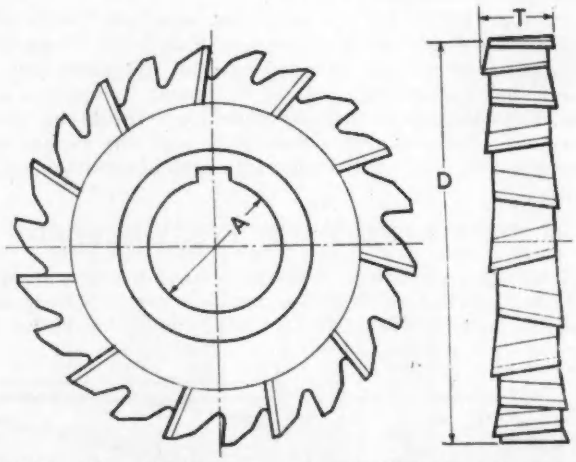


Table No. 5. Stagger Tooth Milling Cutters

Diameter of Cutter D			Width of Face T			Diameter of Hole A		
Nom.	Max.	Min.	Nom.	Max.	Min.	Nom.	Max.	Min.
2 ½	2.515	2.485	¼	.2520	.2490	⅞	.876	.875
2 ½	2.515	2.485	5/16	.3145	.3115	⅞	.876	.875
2 ½	2.515	2.485	⅜	.3770	.3740	⅞	.876	.875
2 ½	2.515	2.485	½	.5020	.4990	⅞	.876	.875
3	3.015	2.985	3/16	.1895	.1865	1	1.001	1.000
3	3.015	2.985	¼	.2520	.2490	1	1.001	1.000
3	3.015	2.985	5/16	.3145	.3115	1	1.001	1.000
3	3.015	2.985	⅜	.3770	.3740	1	1.001	1.000
3	3.015	2.985	½	.5020	.4990	1 ¼	1.251	1.250
3	3.015	2.985	⅝	.6270	.6240	1 ¼	1.251	1.250
3	3.015	2.985	¾	.7520	.7490	1 ¼	1.251	1.250
4	4.015	3.985	¼	.2520	.2490	1 ¼	1.251	1.250
4	4.015	3.985	5/16	.3145	.3115	1 ¼	1.251	1.250
4	4.015	3.985	⅜	.3770	.3740	1 ¼	1.251	1.250
4	4.015	3.985	7/16	.4395	.4365	1 ¼	1.251	1.250
4	4.015	3.985	½	.5020	.4990	1 ¼	1.251	1.250
4	4.015	3.985	⅝	.6270	.6240	1 ¼	1.251	1.250
4	4.015	3.985	¾	.7520	.7490	1 ¼	1.251	1.250
4	4.015	3.985	⅞	.8770	.8740	1 ¼	1.251	1.250
5	5.015	4.985	½	.5020	.4990	1 ¼	1.251	1.250
5	5.015	4.985	⅝	.6270	.6240	1 ¼	1.251	1.250
5	5.015	4.985	¾	.7520	.7490	1 ¼	1.251	1.250
6	6.015	5.985	⅜	.3770	.3740	1 ¼	1.251	1.250
6	6.015	5.985	½	.5020	.4990	1 ¼	1.251	1.250
6	6.015	5.985	⅝	.6270	.6240	1 ¼	1.251	1.250
6	6.015	5.985	¾	.7520	.7490	1 ¼	1.251	1.250
6	6.015	5.985	⅞	.8770	.8740	1 ¼	1.251	1.250
6	6.015	5.985	1	1.0020	.9990	1 ¼	1.251	1.250
8	8.015	7.985	½	.5020	.4990	1 ½	1.501	1.500
8	8.015	7.985	⅝	.6270	.6240	1 ½	1.501	1.500
8	8.015	7.985	¾	.7520	.7490	1 ½	1.501	1.500
8	8.015	7.985	1	1.0020	.9990	1 ½	1.501	1.500

All dimensions in inches.
Side teeth are not cutting teeth.

ciety as promptly as possible. All such comments will be given ample consideration, although it is hoped that the report as submitted will meet with general approval in view of the great amount of work that has been done on it by the Technical Committee.

Correction in Handbook

Attention is called to a typographical error in the Supplement to the 1928 edition of the S.A.E. HANDBOOK on p. 60 under S.A.E. Steel 2320. The Manganese Range given as 0.60—0.80, should read 0.30—0.60. This value is given correctly on the Physical Property Chart on p. 61 and in the table of Chemical Compositions on p. 58.

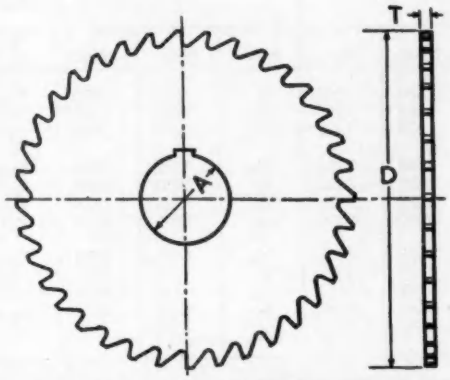


Table No. 6. Metal Slitting Cutters

Diameter of Cutter D			Thickness T			Diameter of Hole A		
Nom.	Max.	Min.	Nom.	Max.	Min.	Nom.	Max.	Min.
2 ½	2.515	2.485	1/32	.0322	.0302	⅞	.876	.875
2 ½	2.515	2.485	3/64	.0478	.0458	⅞	.876	.875
2 ½	2.515	2.485	1/16	.0635	.0615	⅞	.876	.875
2 ½	2.515	2.485	3/32	.0947	.0927	⅞	.876	.875
2 ½	2.515	2.485	⅛	.1260	.1240	⅞	.876	.875
3	3.015	2.985	1/32	.0322	.0302	1	1.001	1.000
3	3.015	2.985	3/64	.0478	.0458	1	1.001	1.000
3	3.015	2.985	1/16	.0635	.0615	1	1.001	1.000
3	3.015	2.985	3/32	.0947	.0927	1	1.001	1.000
3	3.015	2.985	⅛	.1260	.1240	1	1.001	1.000
3	3.015	2.985	5/32	.1572	.1552	1	1.001	1.000
4	4.015	3.985	1/32	.0322	.0302	1	1.001	1.000
4	4.015	3.985	3/64	.0478	.0458	1	1.001	1.000
4	4.015	3.985	1/16	.0635	.0615	1	1.001	1.000
4	4.015	3.985	3/32	.0947	.0927	1	1.001	1.000
4	4.015	3.985	⅛	.1260	.1240	1	1.001	1.000
4	4.015	3.985	5/32	.1572	.1552	1	1.001	1.000
4	4.015	3.985	3/16	.1885	.1865	1	1.001	1.000
5	5.015	4.985	1/16	.0635	.0615	1	1.001	1.000
5	5.015	4.985	3/32	.0947	.0927	1	1.001	1.000
5	5.015	4.985	⅛	.1260	.1240	1	1.001	1.000
5	5.015	4.985	⅛	.1260	.1240	1 ¼	1.251	1.250
5	5.015	4.985	5/32	.1572	.1552	1	1.001	1.000
5	5.015	4.985	3/16	.1885	.1865	1	1.001	1.000
6	6.015	5.985	1/16	.0635	.0615	1	1.001	1.000
6	6.015	5.985	3/32	.0947	.0927	1	1.001	1.000
6	6.015	5.985	⅛	.1260	.1240	1	1.001	1.000
6	6.015	5.985	⅛	.1260	.1240	1 ¼	1.251	1.250
6	6.015	5.985	3/16	.1885	.1865	1	1.001	1.000
6	6.015	5.985	3/16	.1885	.1865	1 ¼	1.251	1.250
7	7.015	6.985	⅛	.1260	.1240	1	1.001	1.000
7	7.015	6.985	⅛	.1260	.1240	1 ¼	1.251	1.250
7	7.015	6.985	1/16	.0635	.0615	1	1.001	1.000
7	7.015	6.985	3/16	.1885	.1865	1 ¼	1.251	1.250
8	8.015	7.985	⅛	.1260	.1240	1	1.001	1.000
8	8.015	7.985	⅛	.1260	.1240	1 ¼	1.251	1.250
8	8.015	7.985	3/16	.1885	.1865	1 ¼	1.251	1.250

All dimensions in inches.
Construction optional; concave sides, hubs; side teeth, undercut or radial.

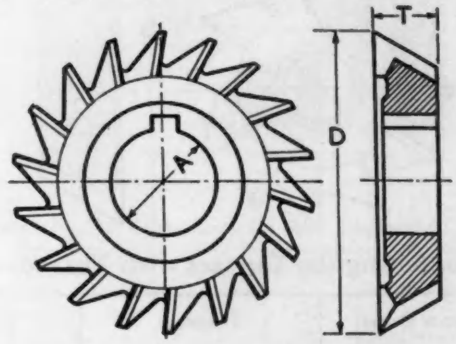


Table No. 7. Single Angle Milling Cutter

Diameter of Cutter D			Thickness T			Diameter of Hole A		
Nom.	Max.	Min.	Nom.	Max.	Min.	Nom.	Max.	Min.
2 ½	2.515	2.485	½	.515	.485	⅞	.876	.875
2 ¾	2.765	2.735	½	.515	.485	1	1.001	1.000
3	3.015	2.985	½	.515	.485	1 ¼	1.251	1.250

All dimensions given in inches.
Angular cutters will be furnished either right or left hand with included angle of 45 or 60 degrees.
Tolerance for angle, plus or minus 10 minutes.

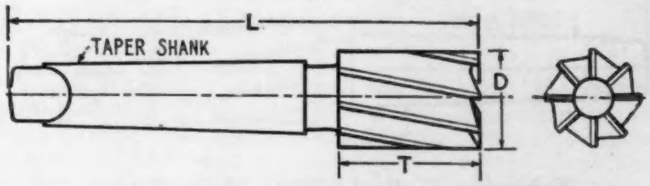


Table No. 10. End Mills—Brown & Sharpe Taper Shank

Diameter of Cutter D			Number of Taper Shank	Length of Cut T	Length Overall L
Nom.	Max.	Min.			
¼	.2600	.2500	5	⅝	2 13/16
5/16	.3225	.3125	5	11/16	2 ⅞
⅜	.3850	.3750	5	¾	2 15/16
7/16	.4475	.4375	5	⅞	3 1/16
½	.5100	.5000	5	15/16	3 ⅛
½	.5100	.5000	7	15/16	4 15/16
9/16	.5725	.5625	7	1	5
⅝	.6350	.6250	7	1 ⅛	5 ⅛
¾	.7600	.7500	7	1 ¼	5 ¼
⅞	.8850	.8750	7	1 7/16	5 7/16
1	1.0100	1.0000	7	1 ⅝	5 ⅝
1 ⅛	1.1350	1.1250	9	1 ¾	7
1 ¼	1.2600	1.2500	9	2	7 ¼
1 ½	1.5100	1.5000	9	2 ¼	7 ½
1 ¾	1.7600	1.7500	9	2 ½	7 ¾
2	2.0100	2.0000	9	2 ¾	8

All dimensions in inches.
Tolerance for length of cut and length overall, plus or minus 1/32 inch.
These end mills are regularly furnished in either right or left hand.
Construction optional, straight or spiral cut type.
End mills with No. 5 B. & S. taper shank are furnished without tang.
Hand of spiral with reference to hand of cut optional with cutter manufacturer.

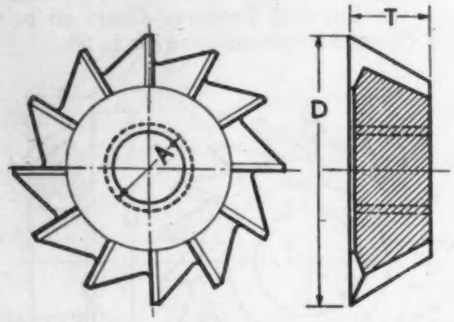


Table No. 8. Angular Cutters with Threaded Hole

Diameter of Cutter D			Thickness T			Hole A	
Nom.	Max.	Min.	Nom.	Max.	Min.	Dia.	No. Threads per in.
1 1/4	1.265	1.235	7/16	452	.422	3/8	24
1 5/8	1.640	1.610	9/16	577	547	1/2	20

All dimensions given in inches.
These cutters will be furnished either right or left hand and with either right or left hand thread.
They have an included angle of 60 degrees.
Tolerance for angle, plus or minus 10 minutes.

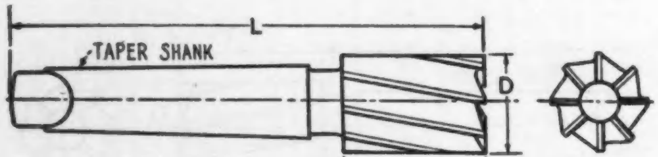


Table No. 11. End Mills—Morse Taper Shank

Diameter of Cutter D			Number of Taper Shank	Length of Cut T	Length Overall L
Nom.	Max.	Min.			
1/4	.2600	.2500	1	5/8	3 1/2
5/16	.3225	.3125	1	11/16	3 9/16
3/8	.3850	.3750	1	3/4	3 5/8
7/16	.4475	.4375	1	7/8	3 3/4
1/2	.5100	.5000	1	15/16	3 13/16
1/2	.5100	.5000	2	15/16	4 7/16
5/8	.6350	.6250	2	1 1/8	4 5/8
3/4	.7600	.7500	2	1 1/4	4 3/4
7/8	.8850	.8750	2	1 7/16	4 15/16
1	1.0100	1.0000	2	1 5/8	5 1/8
3/4	7600	.7500	3	1 1/4	5 9/16
7/8	.8850	.8750	3	1 7/16	5 3/4
1	1.0100	1.0000	3	1 5/8	5 15/16
1 1/8	1.1350	1.1250	3	1 3/4	6 1/16
1 1/4	1.2600	1.2500	3	2	6 5/16

All dimensions given in inches.
Tolerance for length of cut and length overall, plus or minus 1/32 inch.
These end mills are regularly furnished in either right or left hand.
Construction optional, straight or spiral cut type.
Standard in right hand only.
Hand of spiral with reference to hand of cut optional with cutter manufacturer.

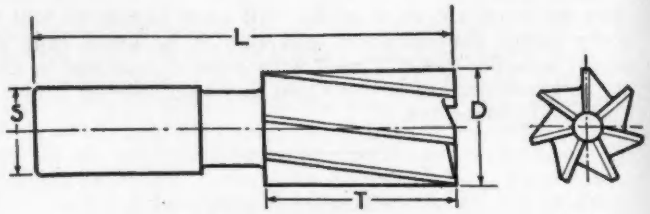


Table No. 12. End Mills—Straight Shank

Diameter of Cutter D			Diameter of Shank S			Length of Cut T	Length Overall L
Nom.	Max.	Min.	Nom.	Max.	Min.		
1/8	.1350	.1250	1/8	.1350	.1250	5/16	1 1/4
5/32	.1663	.1563	5/32	.1663	.1563	5/16	1 1/4
3/16	.1975	.1875	3/16	.1975	.1875	1/2	1 3/8
7/32	.2288	.2188	7/32	.2288	.2188	9/16	1 5/8
1/4	.2600	.2500	1/4	.2600	.2500	5/8	1 11/16
5/16	.3225	.3125	5/16	.3225	.3125	11/16	1 3/4
3/8	.3850	.3750	3/8	.3850	.3750	3/4	1 13/16
7/16	.4475	.4375	7/16	.4475	.4375	7/8	2 3/16
1/2	.5100	.5000	1/2	.5100	.5000	15/16	2 1/4
9/16	.5725	.5625	9/16	.5725	.5625	1	2 5/16
5/8	.6350	.6250	5/8	.6350	.6250	1 1/8	2 1/2
3/4	.7600	.7500	3/4	.7600	.7500	1 1/4	2 5/8

All dimensions given in inches.
Tolerance for length of cut and length overall, plus or minus 1/32 inch.
These end mills are regularly furnished in either right or left hand.
Construction optional, straight or spiral cut type.

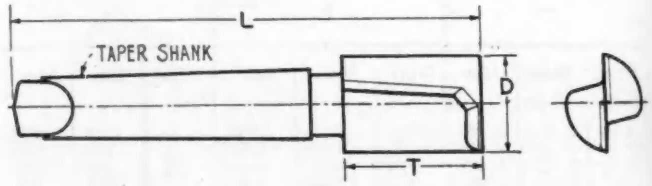


Table No. 13. Slotting End Mills—Two Lipped—B. & S. Taper Shank

Diameter of Cutter D			Number of Taper Shank	Length of Cut T	Length Overall L
Nom.	Max.	Min.			
1/4	.2510	.2490	5	3/8	2 9/16
5/16	.3135	.3115	5	15/32	2 21/32
1/4	.2510	.2490	7	3/8	4 3/8
5/16	.3135	.3115	7	15/32	4 15/32
3/8	.3760	.3740	7	9/16	4 9/16
7/16	.4385	.4365	7	21/32	4 21/32
1/2	.5010	.4990	7	3/4	4 3/4
9/16	.5635	.5615	7	27/32	4 27/32
5/8	.6260	.6240	7	15/16	4 15/16
11/16	.6885	.6865	7	1 1/32	5 1/32
3/4	.7510	.7490	7	1 1/8	5 1/8
13/16	.8135	.8115	7	1 7/32	5 7/32
7/8	.8760	.8740	7	1 5/16	5 5/16
1	1.0010	.9990	9	1 11/16	6 15/16
1 1/8	1.1260	1.1240	9	1 11/16	6 15/16
1 1/4	1.2510	1.2490	9	1 7/8	7 1/8
1 1/2	1.5010	1.4990	9	2 1/4	7 1/2
1 3/4	1.7510	1.7490	9	2 1/2	7 3/4
2	2.0010	1.9990	9	2 3/4	8

All dimensions in inches.
Tolerance for length of cut and length overall, plus or minus 1/32 inch.
These slotting mills are regularly furnished either right or left hand.
Straight or spiral lip optional.
End mills with No. 5 B. & S. taper shank are furnished without tang.

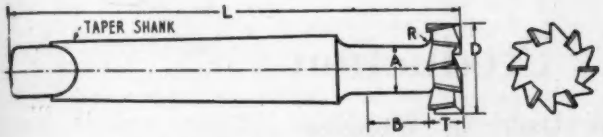


Table 14. T-Slot Cutters—Brown & Sharpe Taper Shank

Nominal Bolt Size	Diameter of Cutter D		Thickness of Cutter T		Diameter of Neck A		Length of Neck B	Fillet Radius R	Number of Taper Shank	Length Overall L
	Max.	Min.	Max.	Min.	Max.	Min.	Min.	Max.		
1/4	.562	.552	.234	.229	.265	.260	3/8	.007	5	2 5/8
5/16	.656	.646	.265	.260	.328	.323	7/16	.007	5	2 23/32
3/8	.781	.771	.328	.323	.406	.401	9/16	1/64	7	4 13/16
1/2	.968	.958	.390	.385	.531	.526	11/16	1/64	7	5
5/8	1.249	1.239	.484	.479	.656	.651	7/8	1/64	7	5 1/4
3/4	1.468	1.458	.625	.620	.781	.776	1 1/16	1/64	9	6 7/8
1	1.843	1.833	.828	.823	1.031	1.026	1 1/4	1/64	9	7 1/4
1 1/4	2.218	2.208	1.093	1.088	1.281	1.276	1 9/16	1/64	9	7 13/16
1 1/2	2.655	2.645	1.343	1.338	1.531	1.526	1 15/16	1/64	10	10 3/8

All dimensions given in inches.
Tolerance: plus or minus 1/64 inch, unless otherwise specified.
T-Slot cutters with No. 5 B. & S. taper shank are furnished without tang.

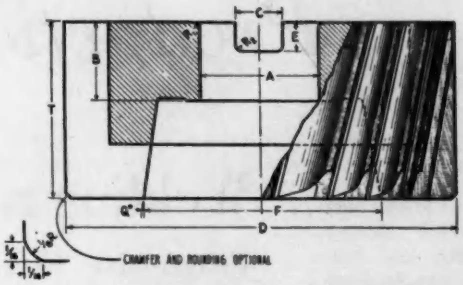


Table No. 15. Dimensions for Shell End Mills

Size or Diam. D	Width of Mill T	Hole				Driving Slot					Counterbore		
		Diameter A		Depth B		Width C		Depth E		Fillet Radius R	Diam.[1] F	Diam.[1] G	Angular Increase Q deg.
		Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.				
1 1/4	1	.5005	.5000	41/64	5/8	.262	.258	11/64	5/32	1/64	11/16	5/8	0
1 1/2	1 1/8	.5005	.5000	41/64	5/8	.262	.258	11/64	5/32	1/64	11/16	5/8	0
1 3/4	1 1/4	.7505	.7500	49/64	3/4	.324	.320	13/64	3/16	1/32	15/16	7/8	0
2	1 3/8	.7505	.7500	49/64	3/4	.324	.320	13/64	3/16	1/32	15/16	7/8	0
2 1/4	1 1/2	1.0005	1.0000	49/64	3/4	.387	.383	15/64	7/32	1/32	1 1/4	1 3/16	0
2 1/2	1 5/8	1.0005	1.0000	49/64	3/4	.387	.383	15/64	7/32	1/32	1 3/8	1 3/16	0
2 3/4	1 5/8	1.0005	1.0000	49/64	3/4	.387	.383	15/64	7/32	1/32	1 11/32	1 3/16	5
3	1 3/4	1.2505	1.2500	49/64	3/4	.512	.508	19/64	9/32	1/32	1 21/32	1 1/2	5
3 1/2	1 7/8	1.2505	1.2500	49/64	3/4	.512	.508	19/64	9/32	1/32	1 11/16	1 1/2	5
4	2 1/4	1.5005	1.5000	1 1/64	1	.637	.633	25/64	3/8	1/16	2 1/32	1 7/8	5
4 1/2	2 1/4	1.5005	1.5000	1 1/64	1	.637	.633	25/64	3/8	1/16	2 1/16	1 7/8	10
5	2 1/4	1.5005	1.5000	1 1/64	1	.637	.633	25/64	3/8	1/16	2 9/16	1 7/8	10
5 1/2	2 1/4	2.0005	2.0000	1 1/64	1	.762	.758	29/64	7/16	1/16	2 13/16	2 1/2	10
6	2 1/4	2.0005	2.0000	1 1/64	1	.762	.758	29/64	7/16	1/16	2 13/16	2 1/2	15

All dimensions in inches.
[1] Tolerances—plus or minus 1/64 inch unless otherwise specified.
Shell End Mills are regularly furnished with spiral teeth in either right or left hand.
Hand of spiral same as hand of cut.

The Hazard of Lightning in Aviation

IT is especially necessary that, in the new field of aviation, where transportation is through the air and between a charged cloud and an induced earth-charge, or between two charged clouds, steps be taken to secure safety. No argument is needed to convince us of the value of the fullest possible knowledge of conditions under which this tremendous electrical energy is developed and dissipated. Let us try to calculate the energy of a moderate streak of lightning.

We shall never control lightning until we manage to slow down the discharge. If the stroke could be delivered gradually, we might devise means to minimize the present destructive effect. There are cases of "corkscrewing" flashes, and there may be something like a progressive breakdown which later knowledge may be able to utilize; but at present, with most flashes, the effect is that due to a large output of power delivered in an extremely short period. Peek's definition of lightning as "an electrical explosion" seems to us to fit the case. At present, neither airplane nor airship is fitted to withstand such a violent shock, development of heat and likelihood of fire.

Many of the destructive effects of lightning can be duplicated on a scale not much reduced from that of the natural discharge. An intense lightning flash can splinter struts, fuse guy wires, tear off the fabric of the plane, and probably kill the aviator.

All that precedes emphasizes the fact that as yet the airman should not knowingly incur the danger incident to the proximity of a highly charged cloud. There is a double danger; first, from the lightning, and, second, from the existence of wind gusts, vertical as well as horizontal, which make it very difficult if not impossible for even a skillful flier to control his airplane. The catastrophe of the Shenandoah may illustrate the latter danger; for it was apparently not the lightning, but the terrific up and down thrusts of the air currents which brought disaster.

Airmen should keep a vigilant lookout for cumulonimbus clouds (thunderheads) and steer a course away from or around them. It is also possible in many cases to fly above a thunderstorm, for many of these are below 3000 m. (9842 ft.)[1]; but a good-sized thunderhead cloud may have its top, owing to the intense convection currents, three times as high as these figures.

The probability of thunderstorms is now indicated at all airports; and in time there probably will be installed electrometric apparatus whereby the potential gradients can be determined and approximate electric-field strengths given. It will also be possible eventually to equip airplanes and airships with devices that will automatically warn of the approach of charged clouds and dangerous conditions. Until this is done, the wisest course is to avoid unnecessary risk. Not every bad-looking cloud is going to cascade its electrical and storm energy into a passing airplane; but the elements of danger are there, and a wise aviator will hesitate to take chances.—Bulletin of the Guggenheim Foundation.

[1][Many authorities would not agree with this. There are relatively few thunderstorms which could be cleared at 3000 m. altitude, and the general experience of aviation indicates that it is bad practice to attempt to fly over.—Editor of the Bulletin.]

Production Engineering

Welding and Body Production

Progressive Production-Line Used in Welding Assembly—Spot-Welding Mars Eliminated

ALL-STEEL body production and welding are almost synonymous, and few companies use various methods of electric and acetylene welding to a greater extent than does the Edward G. Budd Mfg. Co. In a paper read recently before the American Welding Society, J. W. Meadowcroft, assistant works manager of the Budd company, described as follows some of the welding methods in producing Budd bodies.

During the last 14 years the proportions of the different classes of welding used by this company have changed, so that now nearly 70 per cent of the welding is spot-welding; and arc-welding has a very small place. This is due largely to an increase in the amount of flash-welding, which is classified as spot-welding, and to a development of spot-welding with a new design of tapping-blocks and small parts so that this method can be used to better advantage. An example of this substitution is found in the welding together of the inside and outside panels of steel doors. The arc-welding method marred the outer panel so that finishing work was required, while the newly developed oblique spot-welding method leaves the exterior perfectly smooth.

This work is done with the special machine shown in Fig. 1, which was developed in the Budd factory. One of the features of the machine is a transformer designed with a special secondary voltage. Taking off four bolts enables the primary and secondary coils to be removed. The flexible lead energizing the inside panel makes possible the welding of the entire door with one handling. The flexible joint between the cross-bar and the flexible lead is water-jacketed, and the weight of the unit is sufficient to make the contact. The welding operation is foot controlled.

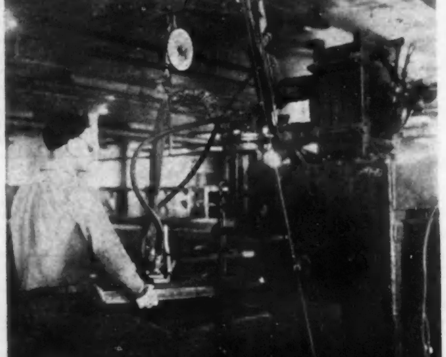


FIG. 1—AN OBLIQUE SPOT-WELDING JOB

FLASH-WELDING THIN METAL

Flash-welding differs from butt-welding and can be used on thinner metal. In butt-welding, the edges of the two parts to be welded are brought together by means of an operating lever and current is applied. A small flash occurs at the first application of current, after which the metals are joined until the metal projecting beyond the welding dies has reached welding heat. At this time additional pressure is applied, the current is cut off, and the weld is made.

For flash-welding there must be a perfect fit between the upper and lower dies. The lower dies, connected directly to the transformers, must be kept in perfect alignment. With the parts clamped in perfect alignment and extending beyond the dies from ¼ to 9/32 in., the current is applied before the edges of the metal come into contact. Higher voltage is used than in the case of butt-welding, and an arc is formed that causes a decided flash as the edges come together. The speed of the machine and the voltage of the transformer secondary are so arranged that the metal

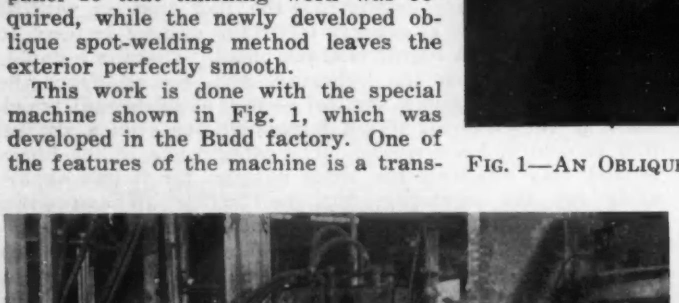


FIG. 2—FLASH WELDING ON A STANDARD WELDING-MACHINE

This View Shows How a Standard Machine Can Be Adapted for Flash-Welding the Seam Joining the Roof Panel to the Rear Quarter of the Body

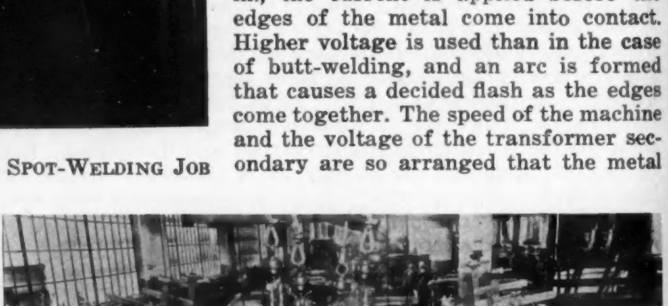


FIG. 3—A LARGE DOUBLE WELDING-MACHINE

This Machine Is Made From Two Standard Units Mounted on a Single Base—It Flash-Welds Two Seams at Once, Each 70 In. Long

is in a plastic state and ready for welding by the time the high point of the operating cam is reached. At this time the power is cut off from the transformer and the actual welding operation is completed.

As the amount of metal extending beyond the welding dies controls the finished weld, it is necessary to have the same amount of metal extend from both dies; otherwise, one piece will be entirely flashed away by the time the other reaches welding heat. When these precautions are taken, Mr. Meadowcroft asserts, the strength of the weld cannot be questioned.

An example of flash-welding is the joining of a roof panel to the rear-quarter panel of a coupé body, as shown in Fig. 2. This job is done on a machine of standard design, manufactured and purchased with a view to its flexibility. The machine shown is rated at 125 kw., is power driven and fully automatic. Machines of the same type have been used for welding cowls.

Welding Two Seams at Once

Two seam flash-welds are made simultaneously in producing a tonneau. The machine used is of standard design, with two individual welding units mounted on one bedplate. Each unit has a 200-kw. transformer, with a welding capacity of 70 in. of 0.043 in. standard body-stock, and is operated by a 2-hp. motor. The total weight of the assembled machine is approximately 52,000 lb., the welding dies are of aluminum bronze, and the pressure developed across the face of the dies is approximately 32 tons. The interior of this machine is shown in Fig. 3.

A modern assembly line is employed in the spot-welding work on the front ends of the bodies for a popular car. The same unit is used for a coupé, sedan or cabriolet, or for a delivery cab, so very high production is possible. Fig. 4 shows a line of machines with the overhead-rail conveyor and the flexible hangers by means of which the work can be raised or lowered and which permit it to be laid over on one side for operations that require this position. Space is provided between the welding units in which such small assembly operations as are required can be done. Portable spot-welding machines are used for some of the operations in the line, and they have eliminated the necessity of using a large number of toggle clamps. The length of the track on this line is 296 ft., and the line accommodates 19 standard upright welding-machines.

The operator on the conveyor line is assigned a certain task, and the work is brought to him by the conveyor in such a way that he does not need to depend upon a helper. There is space between the machines for at least one piece, giving flexibility enough so the welder is not distracted by an effort to make his work synchronize exactly with that of other workers in the line.

The most important operation of the entire assembly is the proper locating of the partly assembled outside shell to the interior strengthening or supporting framework. This is accomplished very successfully by jigging the sub-units in an assembly fixture, by means of specially designed loose toggle-clamps, so that the unit can be assembled and removed from the jig with the minimum number of operations, thus increasing the production of each assembly fixture and decreasing the number of fixtures required. A few spot-welds are placed at fixed points by each operator and the piece is removed.

Spot-welding in the assembly line has eliminated a large number of toggle-clamps, and has been found to be a decided improvement. Once the pieces have been properly aligned and tacked in place by means of the portable welding-machine, they must remain in perfect alignment.

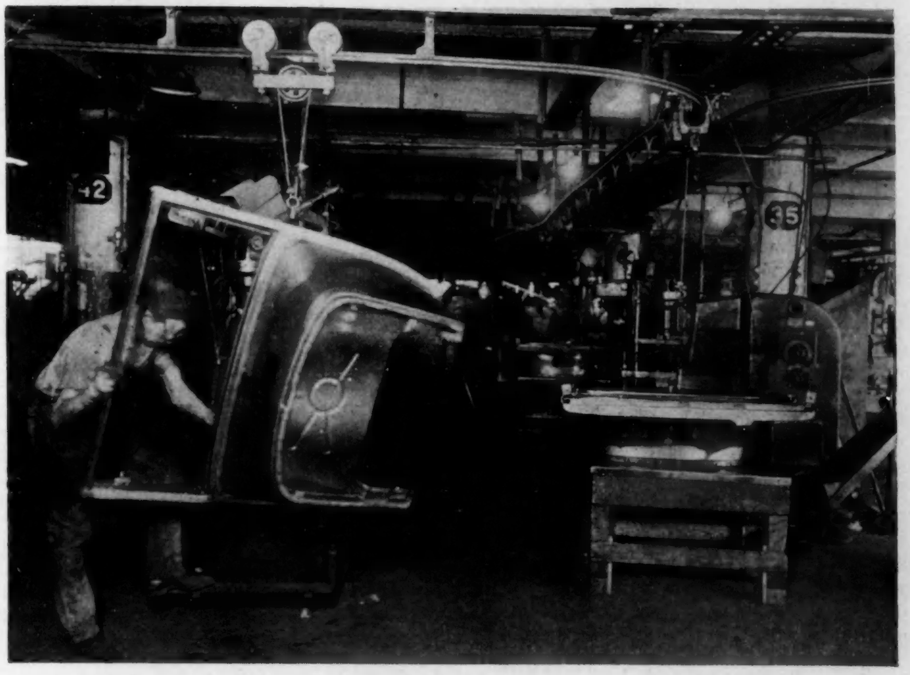


FIG. 4—ASSEMBLY LINE ADAPTED TO WELDING OPERATIONS

The Front Unit of an All-Metal Body Is Suspended from an Overhead Track by Flexible Hangers that Permit the Unit To Be Raised, Lowered and Tilted

Boost Your Meeting

INTEREST of the production men is centered in the meeting in Detroit this month. Read the detailed announcement of it on p. 516.

The production division of the Society is one of the latest models. It has been accelerating gradually from the start to 10 m.p.h., as any car will do when its gearing is suitable for higher speed, and a better acceleration rate from 10 to 20 m.p.h. can be expected. Perhaps the foot has not been quite heavy enough on the accelerator, and a little added pressure is needed from those who would go faster.

Now that consideration is being given to departmentizing the activities of the Society, it is important for production men to show whether they want an active department devoted to their interests. This can be done by attending the Production Meeting and taking part in the discussion, even if it is necessary to shout someone else down. If you cannot attend, you still can help if you will write to the Society for preprinted or mimeographed copies of papers in which you are interested and send in some written discussion for reading at the meeting or for publication in THE JOURNAL. Carefully prepared discussion sometimes is more valuable than many of the extemporaneous remarks.

The habit of participating in S.A.E. meetings has helped many automotive engineers to grow bigger. Every seed of information given returns to the sower a crop of ideas.

Airplane Fuselage Construction

Everyone who has to do with production of airplanes will wish to read Gerard Vultee's paper on the production of the Lockheed Vega airplane fuselages. This paper, which will be found on page 449 of this issue of THE JOURNAL, tells specifically a method of building up a laminated-wood fuselage in a single unit.

Operation and Maintenance

Man-Power Requirements

Number of Men Needed Per Vehicle Operated and Seasonal Labor-Fluctuation

STUDY of the requirements of motor-vehicle fleet-operators in regard to the number of men they employ for operating and maintaining the vehicles was made by Subcommittee No. 4 of the Operation and Maintenance Committee during the last year. As a result, the Subcommittee presented the following report at the Operation and Maintenance Committee session of the Transportation Meeting held Oct. 18 in Newark, N. J.

Report of Subcommittee No. 4

As pointed out in the report of Subcommittee No. 7 on Administrative Systems and Methods, a system of correct accounting of motor-vehicle expense and of calculating statistics in connection therewith is necessary properly to control motor-vehicle operation. The value of all cost systems depends (*a*) on the mechanical make-up of the system itself, and (*b*) the use to which the resultant figures are put. Cost figures should provide a graphic picture of the business at any time at a glance. They should definitely indicate variations from the standard, showing whether expenses on certain items are too heavy or too light, and this in turn will aid in a determination of the cause of the variations. Also, cost figures should enable one operator to compare his operations with those of another in the same line of work.

The cost of maintaining a fleet of motor-vehicles is divided into two natural classifications: material costs and labor costs. Irrespective of what additional expense data the management desires, the lump figures under these two headings must be watched closely by the head of the mechanical department. It is evident that, in an organization of any size, the higher executives cannot personally check time-sheets, or job-tickets, or even material issues. They must be guided by figures covering the whole maintenance work or some particular phase of that work. When there is any unreasonable fluctuation in the figures, the record on which the report is based can be investigated to determine where the inefficiency lies. In railroad operations, in which a uniform classification of accounts and operating statistics is maintained, an operator is able to compare his operations during one period with a previous period, and also with those of other railroads. In motor-vehicle operation it is practically impossible to do this; but, with increase in the size of fleets, increased material and labor costs, and the demand for lower transportation-costs, it is becoming necessary that fleet operators work together to weed out inefficiencies. This can be accomplished only by a comparison of results.

The Subcommittee, to accomplish its purpose, prepared the accompanying questionnaire to determine for comparative purposes the man-power requirements of fleet operators and the cost of maintenance labor and mechanical labor per vehicle per day and per mile of operation. The questionnaire was sent to operators in various parts of the Country and 38 replies were received. A summary of these replies follows:

QUESTIONNAIRE ON MAN-POWER REQUIREMENTS FOR MOTOR-VEHICLE OPERATION

Question No.	Question
1	How many motor-trucks or motor-coaches do you operate?
2	What is the total annual maintenance mileage of your fleet?
3	What percentage of your annual maintenance cost is represented by work done in outside shops?
4	What percentage of your total annual maintenance cost is work done due to accidents?
5	What percentage of your annual maintenance cost is represented by non-productive labor such as clerical help, supervision, stock clerks and the like?
6	What is the average number of men employed for garage service, which includes supplying gasoline, oil and water, routine inspection, tire inflation, adjustment, lubrication and washing?
7	What is the average number of men employed on repair work?
8	If the same crew of men handle both garage and repair maintenance work, what is the total number of men employed for this service and how is their time divided between garage service and actual repair maintenance work? What percentage of time is spent on garage service?
9	How many hours per month do your maintenance men work?
10	How many hours per month are charged to washing and cleaning?
11	What are the maximum and the minimum numbers of maintenance men employed during the year? During what month is the maximum number employed?
12	What is the cost of mechanical labor per vehicle per day?
12a	What is the cost of mechanical labor per vehicle per mile?
13	What is your cost of total maintenance-labor per vehicle per day?
13a	What is your cost of total maintenance-labor per vehicle per mile?

DATA ANALYZED

Annual maintenance-cost percentage represented by work done in outside shops ranges from zero to 75 per cent of the total. Out of 35 companies, 9 reported no work performed in outside shops; 19 reported less than 5 per cent, and 7 companies more than 5 per cent.

Total annual maintenance-cost resulting from accidents, that is, the gross cost of accident repairs without any deduction for amounts recovered from insurance companies or from other parties, as reported by 28 companies, is 1 per cent or less in the case of 15 companies; between 1 and 5 per cent in the case of 7 companies; and more than 5 per cent in the case of 6 companies, ranging up to 22 per cent in one instance.

Non-productive labor, such as clerical help, supervision, stock clerks and the like, ranges from 0.1 to 27.0 per cent of the total annual maintenance-cost, based on the reports of 29 companies. Eighteen reported less than 10 per cent; 9 between 10 and 20 per cent, and 4 over 20 per cent of their total annual maintenance-cost on account of non-productive labor.

The average number of men employed for garage service, which includes supplying gasoline, oil and water, routine inspection, tire inflation, adjustment, lubrication and washing, as represented by the average number of vehicles per man, based on reports from 10 motorcoach companies operating 1156 vehicles and employing 290 men, is one man for every four motorcoaches. As to motor-trucks, 19 companies operating 3929 vehicles and employing 290 men average 13.5 vehicles per man.

The average number of motorcoaches per man employed in repair work on them, based on reports from 10 motorcoach companies operating 1156 vehicles and employing 472 men, is 2.5 per man. As to motor-trucks, 19 companies operating 3929 vehicles and employing 584 men average 6.7 vehicles per man.

TABLE 1— MAN-POWER REQUIRE-MENTS

Details		Motor-coach	Motor-Truck
Number of Companies		10	19
Number of Vehicles		1,156	3,829
Number of Men	Repair	472	584
	Garage	290	290
Average Number of Vehicles per Man	Repair	2.5	6.7
	Garage	4.0	13.5
Total Vehicles per Man, both Repair and Garage		1.5	4.5

TABLE 2—DATA OBTAINED FROM REPLIES TO QUESTIONNAIRE

Reply No.	Type of Operation	Question Nos. 1	2	3	4	5	6	7	8 Men	8 Per Cent	9	10	11 Max. No.	11 Min. No.	11 Max. Mo.	11 Min. Mo.	12	12a	13	13a
	Motor-Truck Operations[1]																			
1	Chain Store Grocer	124	726,432[b]	0.1	0.1	...	3	10	...	...	9[d]	18[d]	10	8	Nov. to Mar.	March to Nov.	0.90	0.04	.....	.....
2	Baker	91	1,218,200	15.0	22.0	5.0	9	10	19	50	220	432	21	18	Feb.	Aug.	0.80	0.0015	1.70	0.0035
3	Packer	81	950,000	70.0	1.0	27.0	3	2	5	70	400	90	10	2	July	Jan.	1.50[e]	0.01	0.70	0.015
4	Contract Carrier	129	774,892	8.0	0.003	25.0	11	25	...	...	203	203	None	None	....	....	0.47[f]	0.03	1.00[g]	0.07
5	Oil Company	766	4,867,227	2.0	1.0	3.5	6	57	60	40[c]	234	1,404[h]	57	57	....	....	0.60[i]	0.08	0.68	0.022
6	Laundry	68	....	None	10.0	15.0	3	6	...	...	200	200	10	5	Dec.	July	.....	.....	1.25	.....
7	(Not Stated)	124	1,035,675	....	.....	....	...	...	...	...	.....	.....	.....	.....	....	....	.....	.....	.....	.....
8	Baking	346	4,544,700	2½	5.0	12.5	29	18	...	...	234	3,276	None	None	None	None	0.57	0.014	0.69	0.019
9	Manufacturer	62	620,000	....	...	....	...	...	...	...	.....	.....	.....	.....	....	....	.....	.....	.....	.....
10	Manufacturer	109	640,000[s]	25.0	...	6.8	6	9	...	...	48[j]	450	None	None	None	None	.....	0.0066	.....	.....
			428,000[t]	....	...	...	...	...	...	...								0.0498		
			1,068,000[u]	....	...	...	...	...	...	...										
11	(Not Stated)	78	742,488	16.4	1.0	18.7	3	4	...	...	215	435	8	7	Dec. to April	April to Dec.	0.286	0.008	0.753	0.021
12	State Highway Department.	1,164	2,000,000	None	0.25	5.0	...	...	...	...	.....	.....	.....	.....	Jan. to Feb.	Oct. to Nov.	.....	.....	.....	.....
13	Department Store	60	1,054,445	....	0.03	10.0	4	5	...	...	225	.....	11	9	Dec.	Balance of year	0.50	0.052	0.914	0.014
14	Manufacturer	50	292,000	3.0	0.5	None	5	3	...	...	770	130	8	8	....	....	0.50	0.028	1.05	0.053
15	Department Store	104	822,277	18.0	3.0	8.0	5	8	...	...	8[d]	.....	13	13	....	....	0.57	0.017	0.85	0.025
16	Public Utility	373	3,192,894	75.0	2.0	10.0	23	8	...	...	192	576	23	23	....	....	0.09	0.004	0.17	0.074
17	Common Carrier	879	8,690,556	None	0.0261	7.19	119	244	...	...	209	2,108	363	363	....	....	1.24	0.0538	2.10	0.0892
18	Municipal	147	5,600?	3.0	5.0	20.0	4	8	...	...	60[j]	184[j]	10	5	Summer	Balance of year	0.43[k]	0.10	0.68[k]	0.17
19	Ice	136	956,800	2.1	1.7	14.0	8	7	...	...	4,410	1,440	15	15	....	....	0.50	0.026	0.71	0.037
20	Oil	853	7,215,000	2.5	...	18.2	32	121	...	...	212	.....	.....	Constant	....	....	0.369[l]	0.0107	1.038	0.0301
21	Contract Carrier	125	1,586,178	3.5	0.2	5.0	3	15	...	...	260	0[m]	15	14	....	....	0.50	0.018	9.72	0.0248
22	Public Utility	126	507,000[s]	3.3	0.7	7.8	6	6	...	...	254[n]									
			468,000[t]	....	...	...	...	...	...	...	217[o]	254	12	12	....	....	0.373	0.015	0.704	0.0284
			975,000[u]	....	...	...	...	...	...	...										
36	Department Store	79	889,860	2.0	1.0	0.5	12	17	...	...	234	1,250	None	None	....	....	0.099	0.027	0.224	0.056
37	Department Store	321	2,681,798	4.97	0.83	3.0	...	6	80	20	1,350	16,200	88	77	August	Dec.	0.98[r]	0.012	2.54	0.032
38	Department Store	104	1,008,686	5.5	7.4	12.4	4	12	...	...	208	416	4	4	....	....	0.675	0.0176	0.237	0.0062
	Motorcoach Operations[2]																			
23		37	1,379,638	20.0	0.02	0.01	27	17	...	...	240	720	25	17	Jan Feb. March	April May June July	3.00	0.009	9.52	0.058
24		22	775,368	None	...	...	4	8	...	...	260	520	8	7	Summer	Winter	1.88[p]	0.014[p]	4.96[g]	0.033[g]
25		97	5,158,000	0.02	2.6	21.7	...	...	43	...	285	1,710	None	None	....	....	1.42	.....	?	?
26		53	1,200,000	0.5	...	5.0	12	8	...	...	175	.....	8	8	....	....	.....	.....	.....	.....
27		61	1,500,000	5.0	...	10.0	10	25	...	...	176	1,400	35	33	Winter	Summer	2.16	0.018	3.00	0.0250
28		29	525,513	1.0	11.0	24.0	6	8	...	...	260	300	10	7	July Aug.	Jan.	2.50	0.0181	3.66	0.0407
29		337	20,000,000	1.0	0.5	7.0	80	280	...	...	236	5,040	300	200	June July August	Dec. Jan. Feb.	7.00	0.035	8.00	0.005
30		262	6,071,466	None	5.5	12.0	46	55	...	...	208	4,200	None	None	....	....	.....	0.0582	.....	.....
31		120	3,715,000	None	...	10.7	7	...	...	...	225	1,350	50	35	Feb.	July August	2.00[q]	0.024	2.95	0.035
32		148	4,798,309	None	...	...	...	...	100	...	224	.....	.....	.....	....	....	.....	.....	.....	.....
33		100	4,200,000	3.0	15.0	10.0	50	30	...	...	270	1,460	40	30	Dec.	March	2.50	0.011	240.00	0.02
34		41	2,190,858	None	1.5	....	10	7	...	...	275	825	10	7	Dec.	July	1.75	0.0195	.....	.....
35		153 61[a]	2,265,637	None	...	5.8	45	34	...	...	176	4,687	89	69	July August Sept.	Jan. Feb.	1.02	0.0247	.....	.....

[1]Geographical location of companies: New York, 12; Pennsylvania, 5; Michigan, 2; Colorado, 1; Indiana, 1; Ohio, 1; Massachusetts, 1; Missouri, 1; Wisconsin, 1.

[2]Geographical location of companies: Florida, 1; Illinois, 2; Indiana, 1; Kentucky, 1; New York, 1; New Jersey, 1; North Carolina, 1; Ontario, Canada, 1; Pennsylvania, 1.

[a]Motor-trucks. [b]Trucks over 2-ton capacity only; no mileage record kept on smaller sizes. [c]Vehicles scattered over 15 States. [d]Per day. [e]Heavy duty only. [f]Based on 300 operating days per year. [g]Includes supervision and all garage and maintenance employes. [h]In addition truck operators do this work and this is charged to cost of drivers. [i]Includes cars and trucks. [j]Per week. [k]Cost of painting and body repairs not included. [l]All figures based on operating days. [m]Drivers do this work. [n]Night crew. [o]Day crew. [p]Does not include body. [q]Includes material. [r]Direct labor only. [s]Trucks. [t]Passenger-cars. [u]Total.

Table 1 shows that, for the total number of men employed, including those engaged in repair work and those assigned to the garage, there are in the case of 19 companies operating 3929 motor-trucks and employing a total of 584 men, an average of 4.5 vehicles for each man. As to motorcoaches, 10 companies operating 1156 vehicles and employing a total of 762 men average 1.5 motorcoach for every man.

Table 2 shows major details of the data obtained for motor-trucks and motorcoaches.

Time Spent on Maintenance

Only 6 of 38 companies reporting answered the question whether the same crew of men handles both garage and repair maintenance-work, which implies that in most instances the same crew does not handle both the garage and repair maintenance-work.

The average number of hours worked by employes of the maintenance department, based on the reports of 15 companies operating motor-trucks, is 221 hr. per month; in the case of motorcoaches, based on the reports of 13 companies, it is 231 hr.

According to the reports of 15 companies operating 3684 motor-trucks, 29,015 hr. per month were charged to cleaning and washing, which is an average of 7.9 hr. per month charged to each vehicle for these items. As to motorcoaches, 11 companies operating 1320 vehicles reported a total of 22,212 hr. per month charged to the washing and cleaning of vehicles, or an average of 16.8 hr. per month per vehicle.

Seasonal Variations Not Great

Seasonal variation as a factor affecting the number of maintenance men employed during the year is not of great importance, as shown by the reports of 17 companies operating motor-trucks. The maximum number of men employed by these companies totals 670, while the minimum totals 640 men, a difference of only 30 throughout the year. Six companies reported no variation. Only nine reported as to the month in which the maximum number of men are employed and, of these, seven reported the maximum during the winter months and two during the summer.

As to motorcoach operation, 10 companies reported a total of 575 as the maximum number of employes during the year and a minimum total of 413, a difference of 162 or 28 per cent. Of nine companies reporting the months in which the maximum number of men are employed, five reported the largest number during December, January and February, and four companies during June, July and August. Three reported no variation throughout the year.

Shopwork and Costs

Of the 38 reports, the following numbers of companies reported that they perform in their own shops the classes of maintenance listed below:

Class of Maintenance	Number of Companies
Electrical	33
Carbureter	35
Tires	15
Radiators	15
Painting	29
Body Repairs	30
Welding	32
Rebuilding complete units such as axles, etc.	37

The cost of mechanical labor and the total maintenance cost per day and per mile are also reported by the various companies and can be found easily in Table 2. It is evident that, for comparative purposes, the cost figures are not as valuable as we might desire, because of the lack of uniformity in accounting nomenclature and classifications. Until some agreement has been reached as to nomenclature and cost-accounting practices, it will be difficult to obtain worthwhile results.

F. C. Horner, *Chairman.*

Subcommittee Reports Reviewed

Operation and Maintenance Committee Considers Them Prior to the Transportation Meeting Session

When the Society's Operation and Maintenance Committee for 1928 was organized, seven general projects were assigned to as many Subcommittees for study and the preparation of reports for presentation and discussion at the Committee's session of the S.A.E. National Transportation Meeting to be held in Newark, N. J., Oct. 18. Reports prepared by six of these Subcommittees were reviewed at the general meeting of the Operation and Maintenance Committee on Oct. 16, in Newark, the night before the opening of the Transportation meeting.

It was decided that the reports, after presentation at the Transportation Meeting, were to be published in The Journal, together with the principal discussion of each report. The report of Subcommittee No. 4, on Man-Power Required per Vehicle Operated, is published herewith in this department. Chairman R. E. Plimpton's report and those of the other Subcommittees are scheduled for publication in subsequent issues.

Future Activities Considered

The Committee also discussed plans for its future activities and indicated that, at least partly as a result of the Subcommittees' reports, it will not be long before standards relating principally if not entirely to motor-vehicle fleet-operation will be desired. The Committee therefore indicated that a Motor-Vehicle-Operation Division of the Standards Committee might properly be authorized by the Council for 1929. The form in which such standards might best be published by the Society was considered also, it being the opinion of most of those present that they should be in an Operation and Maintenance Section of the S.A.E. Handbook. It was felt, however, that this phase of the matter should be given further consideration.

A general report of the work of the Operation and Maintenance Committee in all departments of the Society's activities was also reviewed. This report was presented on Oct. 18 at the Transportation Meeting by R. E. Plimpton, Chairman of the Committee. The recommendations embodied in his report undoubtedly will be given further consideration by the members of the Operation and Maintenance Committee and taken up by the several departments of the Society to which they relate, looking toward the further development of the Society's activities for the members whose primary interests are motor-vehicle operation and maintenance.

Desires More Operation Publicity

It was suggested by Chairman Plimpton that, although the S.A.E. Handbook is limited to standards and practices relating to design and construction, many of these are of value to the operation and maintenance members, who could use them to advantage to a much greater extent than is believed to be the practice. A point of criticism raised was that Part 1 and Part 2 of the 1927 Transactions soon to be published are not scheduled to contain papers of distinctive interest to operation and maintenance members, and it was stated that the Committee feels that a fair proportion of the space in the Transactions should be allotted to meritorious papers of special interest to operation and maintenance members.

With regard to the work of the Research Department of the Society, it was suggested that the department of The Journal entitled Notes and Reviews can well be expanded to include valuable transportation information which appears from time to time in articles in periodicals published in the interest of the coal, milk, furniture-moving, and other industries, as such information ordinarily is not readily accessible to the majority of operation

(*Concluded on page* 515)

Agricultural Machinery and Tractors

THE manufacture of farm machinery occupies a peculiar position among the larger industries in that its products are sold to but one class of customer—the farmer. The prosperity of this industry largely depends, therefore, upon the returns received by farmers from the sale of their products. Since 1924 the agricultural sections of the Country, except for the setback that occurred in 1926, have experienced a slow but consistent increase in annual income. This improvement has arisen partly in consequence of higher prices for farm products and partly by virtue of larger crops in certain instances. The aggregate purchasing power of the Nation's farming community, however, which represents the volume of actual goods received in exchange for agricultural products, has risen even more rapidly than farmers' income because of the concomitant decline in the prices of non-agricultural commodities and the reduction of costs through the use of more efficient methods.

Notwithstanding the unfavorable planting and harvesting conditions that prevailed last year, the volume of sales of agricultural machinery, as reported by 90 manufacturers to the Federal Reserve Bank of Chicago, advanced 5.2 per cent over the total of 1926. This expansion was ascribed principally to the improved financial position of the farmer last year and the increasing realization on the part of the agricultural sections of the economies inherent in labor-saving methods. The increasing tendency toward farm mechanization is perhaps the most vital factor for the future of the industry.

Before any crop can be raised, the soil must be prepared for planting and, after ripening, the crop has to be harvested. In these two principal divisions of the farmers' work there are employed the heavy type of implement for plowing and cultivating, and lighter machines for harvesting, binding, husking, raking and so forth.

By virtue of the fact that the power necessary to motivate both these types of implement is supplied by the tractor, this machine is the most essential mechanical device utilized in machine-farming. Of a total of 16,000,000,000 hp-hr. developed in 1925, it is estimated by the Department of Agriculture that about 16 per cent was supplied by gasoline and steam tractors. The fact that such a relatively small portion of the estimated power on American farms is furnished by machinery, and that practically all phases of farm work can be efficiently performed by mechanical means, emphasizes the vast proportions of the potential market for agricultural machinery. Recent developments in tractor manufacture have perfected the machinery so that its operation is as dependable as that of the automobile.

The tendency toward consolidation of farms into larger units and the reduction of crop-raising costs are benefiting the implement companies and at the same time aiding the farming class to operate profitably at existing price levels.

The aggregate value of production of agricultural machinery, tractors and farm vehicles, which increased to $461,400,000 in 1926 from a total of $209,640,000 for 1922, has been characterized by an increasing relative importance of tractor output. In 1922 the value of tractors produced amounted to about 25 per cent of the total output of farm machinery, while by 1926 this percentage had risen to 31.6 per cent.

While the total volume of farm-implement sales has shown a marked advance since the 1920-1921 depression, this development has been accompanied by a decline in the number of concerns engaged in the industry, a decrease in the number of workers employed, and a general reduction in the price per unit. Average employment in concerns reporting to the Federal Reserve Bank of Chicago declined in 11 months last year from the corresponding period of 1926. The number of wage earners in 1925 was 41 per cent less than in 1914, while the establishments decreased from 601 to 303.—*The Guaranty Survey.*

Operation and Maintenance

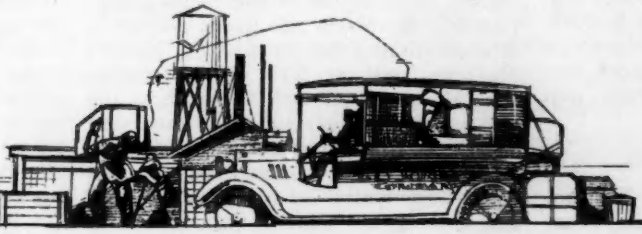
(*Concluded from page* 514)

and maintenance members. A further suggestion was that subjects concerned with the economics of motor transport be taken up by the Research Committee, and the recommendation was made that the Society should make a start in such a study without depending upon outside assistance.

Other Phases of Operation

SEVERAL papers and reports of special import to members interested in operation and maintenance appear elsewhere in this issue of THE JOURNAL. Dr. Miller McClintock, of the bureau for street traffic research at Harvard University, and probably the foremost authority in America on highway traffic and means for expediting and directing the movement, treats the subject Remedies for Traffic Congestion. His paper begins on p. 443. Short-Haul Transportation is discussed on p. 447 by A. T. Warner, of the Public Service Corporation of New Jersey.

In the reports of Section meetings will be found an outline on p. 527 of the practice of a California motorcoach company as regards the Selecting and Training of Motorcoach Drivers. The account of the October meeting of the New England Section, on p. 533, contains some important points discussed in the four papers on Fleet Maintenance that were presented. The traffic-accident situation was discussed at the Buffalo Section meeting by Henry Seilheimer, district manager of the Bureau of Motor Vehicles of the State of New York, and an outline of his address appears on p. 528.



Production Meeting—Nov. 22 and 23

Five Technical Sessions Scheduled at Book-Cadillac—Detroit Section to Hold Production Dinner the First Night

IF the number of requests for preprints of the production papers to be presented at the National Production Meeting, to be held at the Book-Cadillac, Detroit, Nov. 22 and 23, is any criterion, the 1928 Production Meeting will be one of the most worthwhile and successful Production Meetings ever held. More than 300 requests for copies of the papers were received within three days after the first notice of the program was mailed to members.

The complete list of papers and reports to be presented at the meeting is given in the accompanying program. Preprints of the papers are being prepared so that members planning to attend the sessions will have an opportunity to study them prior to the discussion.

The Production Dinner

Thursday evening, Nov. 22, the Detroit Section of the Society will be host to the attending production members and guests at the Detroit Section Production Dinner. The principal speaker at the dinner will be K. T. Keller, who is vice-president in charge of manufacturing for the Chrysler Corp. Members who have already heard Mr. Keller will look forward to the opportunity of hearing him. He will discuss that phase of engineering which lies between the engineering development and design of a car and its production by the line organization in the shop.

According to Mr. Keller, there has grown up in the automotive industry during recent years a mechanical engineering field which is creating new methods of fabricating and is contributing valuable suggestions to the car-engineering departments. The opportunity for further development in this field of endeavor is unlimited. The organization which has developed might well be regarded as a buffer department between the creators and the producers. When such a department is properly organized and staffed with capable men, it should unshackle the car engineer and give him opportunity to express his progressive conception of parts that are lighter, stronger and better adapted to the vehicle which from year to year the public expects to be faster, easier to handle and more stable, with better riding-qualities and better appointments.

To Discuss S.A.E. Reorganization

In addition to Mr. Keller, E. P. Blanchard, Chairman of the Production Committee of the Society, will address the Production Dinner. He will outline the plans of the Committee with special reference to the reorganization of the Society along professional lines, as recommended in the October issue of The Journal, p. 410. Members interested in having the Society take an active part in the production problems of the industry—through the holding of production meetings, both National and Sectional, and the carrying on of committee investigations of important problems—should plan to follow the production activities of the Society closely and participate actively under the proposed reorganization.

The Detroit Section announces that during the dinner very interesting entertainment will be furnished by an orchestra and several vaudeville numbers. The cost of the dinner, which will be informal, is \$3.50 per plate. Reservation blanks for the dinner will be mailed early in November. An attendance of over 500 is expected.

Members of the S.A.E. Production Advisory Board have been invited to attend the dinner as guests of the Detroit Section. They are DuBois Young, president and general manager of the Hupp Motor Car Corp.; F. E. Moskovics, president and general manager of the Stutz Motor Car Co.; F. T. Ellis, vice-president in charge of manufacturing of the Cadillac Motor Car Co.; and A. R. Glancy, president and general manager of the Oakland Motor Car Co.

Opening Session

Two papers of general interest will be presented at the opening session of the technical program on Thursday morning. The first, on How the Ford Motor Company Gets Its Low Production Costs, is by John Younger, and the discussion of this paper should afford an opportunity for an interesting cross-fire on what is possibly the most important production development of recent years.

Accounting for Depreciation as a Production Cost will be discussed by L. A. Baron, comptroller of the Stutz Motor Car Co. Members who heard George T. Trundle discuss Net Profit from Modern Machine-Tools at last year's Production Meeting will look forward to the opportunity of hearing Mr. Baron, who will discuss the question of depreciation, presenting logical reasons for using depreciation as a production cost and setting up reserves which can be obtained easily and applied directly to the replacement of equipment. His paper will include information on this phase that is being compiled as a result of a questionnaire which has been sent to a group of members of the National Association of Cost Accountants.

In addition to these papers, reports are to be submitted by G. W. Blackinton, of the Continental Motors Corp., on the work of his Subcommittee on Process and Equipment, and by H. P. Harrison, of the H. H. Franklin Mfg. Co., on the work of his Subcommittee on Production Expense. Interesting data on the use of diamond tools may be expected from Mr. Blackinton.

Thursday Afternoon Session

P. L. Tenney, of the Muncie Products Division, will preside at the Thursday afternoon session, at which three papers will be presented, two of them devoted to gearing problems and the third to recent developments in honing.

Although the Barnes Gear-Shaver Process, which H. D. Tanner, of the Pratt & Whitney Co., will discuss, is generally known, a discussion of the application of the method should prove of real interest. The paper will be given in abstract only, so that ample time will be allowed for discussion.

The second paper on gears is by A. B. Cox, consulting engineer, who proposes integral-contact gearing as solving the mystery of gear-tooth breakage, wear and noise. A decided difference of opinion exists as to the relative merits of short teeth and teeth that are long enough for two pairs to be working at all times; general discussion should therefore be of great value in bringing out the relative advantages and disadvantages.

At the 1927 Production Meeting, M. C. Hutto's paper on Developments in Cylinder Grinding attracted much attention. In the paper to be presented this year on recent developments in honing, C. G. Williams, of the Barnes Drill Co., discusses honing-machines of several makes and types, treating the subject from the process standpoint. Discussion of this paper should reveal the present status of honing in the automotive industry.

At this session, also, a report will be submitted by Chairman L. F. Maurer on the work of his Production Standards Subcommittee, which has been studying the need and possibilities of publishing recommended practices and methods for production.

Material-Handling Session

Every production engineer should be interested in material handling and plan to attend the Friday morning session, at which Vincent P. Rumely, of the Hudson Motor Car Co., will preside. The three papers to be presented constitute a complete treatment of this subject. N. H. Preble, who will give the paper on Assembly-Plant Layout for Material Handling, is one of the officers of Mechanical Handling Systems, Inc., Detroit, and is thoroughly versed in the handling of materials by means of conveyors.

The topic to be discussed by E. C. Broome, namely, The Selection of Conveyor Power Units, is highly important in view of the difficulty so often experienced in selecting units of the proper size and applying them properly. Mr. Broome, who is connected with the Gears & Forging Co., of Cleveland, is well qualified to discuss the subject, as he has been in the technical branch of power-unit design and application for many years.

The third paper at this session will be devoted to a technical discussion of the Possibilities and Limitations of Conveyor-Chain Curvature. J. B. Webb, who will present it, is president of the J. B. Webb Co., of Detroit. Mr. Rumely, as Chairman of the Material Handling Subcommittee, also will submit a report on the work of his Committee.

Power-Transmission Session

Friday afternoon the subject of power-transmission by belt, chain and other types of drive will be discussed, with particular reference to Power-Transmission Engineering as an Economy, the subject of W. W. Nichols' paper. This is a subject of vital importance to every production engineer. Mr. Nichols' paper points out that tremendous production losses result from the improper selection and maintenance of belting, and shows how economies can be effected. An additional paper, discussing the Chain Drive and Its Applications, will be given by A. C. Woodbury, of the Editorial Department of the Society. The discussion of these papers should prove of great value in view of the importance of stopping the production losses now existing in most plants.

Friday Evening Session

Two papers to be delivered at the evening session also should prove of genuine interest. The first is by Paul Geyser, who needs no introduction at Production Meetings of the Society, on the Interpretation of Production Records. Mr. Geyser believes that simple, adequate records can help to obtain a degree of cooperation among all production executives and foremen that will result in substantial savings in operating costs. In the second paper L. W. Haskell, of Dodge Bros., Inc., will

Production Meeting Technical Program

Nov. 22 and 23, 1928 — **Book-Cadillac, Detroit**

Thursday, Nov. 22

10 A. M.—Opening Session

E. P. Blanchard, *Chairman*

Work of Subcommittee on Process and Equipment—Chairman G. W. Blackinton (Report).

How the Ford Motor Company Gets Its Low Production Costs—John Younger, Ohio State University.

Accounting for Depreciation as a Production Cost—L. A. Baron, comptroller, Stutz Motor Car Co.

Work of Subcommittee on Production Expense—Chairman H. P. Harrison (Report).

2 P. M.—Afternoon Session

P. L. Tenney, *Chairman*

Work of Production Standards Subcommittee—Chairman L. F. Maurer (Report).

The Barnes Gear-Shaver Process—H. D. Tanner, Pratt & Whitney Co.

Integral-Contact Gearing—A. B. Cox, consulting engineer.

Cylinder-Honing Progress—C. G. Williams, Barnes Drill Co.

6:30 P. M.—Detroit Section Production Dinner

Production Address—K. T. Keller, vice-president in charge of manufacturing, Chrysler Corp.

Friday, Nov. 23

10 A. M.—Material-Handling Session

V. P. Rumely, *Chairman*

Work of Material-Handling Subcommittee—Chairman V. P. Rumely (Report).

Assembly Plant Layout for Material Handling—N. H. Preble, Mechanical Handling Systems, Inc.

Selection of Conveyor Power Units—C. E. Broome, Gears & Forging Co.

Possibilities and Limitations of Conveyor-Chain Curvature—J. B. Webb, J. B. Webb Co.

2 P. M.—Power-Transmission Session

G. Walker Gilmer, *Chairman*

Power-Transmission Engineering as Affecting Production and Cost—W. W. Nichols, D. P. Brown & Co.

Chain Drives and Their Industrial Applications—A. C. Woodbury, Society of Automotive Engineers.

Prepared discussion on chain and other types of drive and on actual savings effected by adequate belting, by production engineers.

8 P. M.—Evening Session

Guy Hubbard, *Chairman*

Interpretation of Production Records—Paul Geyser, General Motors Truck Co.

The Relation of Time-Study to Manufacturing—L. W. Haskell, Dodge Bros., Inc.

Work of Time-Study Subcommittee—Chairman Eugene Bouton (Report).

Production Meetings of the Society—Guy Hubbard (Report).

discuss the Relation of Time-Study to Manufacturing.

In addition to these papers, subcommittee reports will be made by Eugene Bouton, Chairman of the Time-Study Subcommittee, and Guy Hubbard, Chairman of the Subcommittee on Sections and Meetings.

PRODUCTION MEETING COMMITTEE

During the Production Meeting the various subcommittees of the S.A.E. Production Committee will report on the work they have been carrying on during the last year. For the information of members who have not had an opportunity to follow this activity, the personnel of the several committees is given herewith.

PRODUCTION COMMITTEE

E. P. Blanchard, *Chairman*, Bullard Machine Tool Co.

MATERIAL-HANDLING SUBCOMMITTEE

V. P. Rumely, *Chairman*, Hudson Motor Car Co.
C. C. Martin, Miller-Hurst Corp.
N. H. Preble, Mechanical Handling Systems, Inc.

PRODUCTION STANDARDS SUBCOMMITTEE

L. F. Maurer, *Chairman*, Pierce-Arrow Motor Car Co.
F. W. Stein, Fairbanks, Morse & Co.
David Ayr, Pratt & Whitney Co.
F. M. Bender, Lycoming Mfg. Co.
Jo Berge, Crowner Co.
Eugene Bouton, Chandler-Cleveland Motors Corp.
R. A. DeVlieg, Chrysler Corp.
A. R. Fors, Continental Motors Corp.
H. P. Harrison, H. H. Franklin Mfg. Co.
O. C. Kavle, Manufacturers' Consulting Engineers.
F. E. A. Klein, Pierce-Arrow Motor Car Co.
W. P. Michell, International Motor Co.
D. W. Ovaitt, Buick Motor Co.
E. N. Sawyer, Cleveland Tractor Co.
W. C. Thiel, Waukesha Motor Co.

SECTIONS ACTIVITIES ON PRODUCTION SUBCOMMITTEE

Guy Hubbard, *Chairman*, National Acme Co.
J. B. Armitage, Kearney & Trecker Corp.
A. R. Fors, Continental Motors Corp.
Erik Oberg, *Machinery*, Industrial Press.
John Younger, Ohio State University.

PROCESSES AND EQUIPMENT SUBCOMMITTEE

G. W. Blackinton, *Chairman*, Continental Motors Corp.
F. H. Colvin, *American Machinist*.
G. Walker Gilmer, Jr., Hotel Lewis, Detroit.
W. P. Michell, International Motor Co.
W. W. Nichols, D. P. Brown & Co.
W. W. Norton, Counties Motor Co.

TIME-STUDY AND PERSONNEL RELATIONS SUBCOMMITTEE

Eugene Bouton, *Chairman*, Chandler-Cleveland Motors Corp.
Harry Ford, Cadillac Motor Car Co.
J. C. Mottashed, Hudson Motor Car Co.
William Bayes, White Motor Co.

PRODUCTION EXPENSE SUBCOMMITTEE

H. P. Harrison, *Chairman*, H. H. Franklin Mfg. Co.
W. J. O'Neil, Chrysler Corp.
E. N. Sawyer, Cleveland Tractor Co.
E. W. Weaver, Trundle Engineering Co.

Aeronautic Meeting at Chicago

Aeronautical Chamber of Commerce Cooperating in the Holding of Technical Sessions on Dec. 5 and 6

MEMBERS of the Society who are interested in aeronautics are now looking forward to the Aeronautic Engineering Meeting of the Society and the Aeronautical Chamber of Commerce of America, which will be held at the Hotel Stevens, Chicago, Dec. 5 and 6. These dates fall on Wednesday and Thursday of the week of the International Aircraft Exposition.

In addition to the three technical sessions planned for the meeting, there is to be a meeting of the Aeronautic Standards Committee and a joint conference with the Commercial Manufacturers' Section of the Chamber.

Four papers will be presented at the Powerplant Session scheduled for Dec. 5. Captain Woolson will discuss the application of the Diesel principle to aircraft engines as exemplified by the recent work of the Packard Motor Car Co. in developing a Diesel aircraft engine that has been used successfully in several short flights in Detroit. S. D. Heron, of Wright Field, will present a comprehensive paper on Non-Radial Air-Cooled Engines. Mr. Heron's eviable experience in the development of engines of this type assures a very interesting paper that will be of considerable value to aircraft engine manufacturers. The Maintenance of Air-Cooled Engines in Commercial Operation is to be described in a joint paper by L. S. Hobbs, of the Pratt & Whitney Aircraft Co., and Edward Hubbard of the Boeing Air Transport Co. The

THE LOS ANGELES AERONAUTIC MEETING IN SEPTEMBER RECEIVED MUCH PACIFIC COAST PUBLICITY

Aeronautic Meeting Program

Hotel Stevens, **Wednesday, Dec. 5** **Chicago**

9:30 a. m.—Powerplant Session

Diesel Engines for Aircraft—L. M. Woolson, Packard Motor Car Co.

Maintenance of Air-Cooled Engines in Commercial Operation—L. S. Hobbs, Pratt & Whitney Aircraft Co., and Edward Hubbard, Boeing Air Transport Co.

Airplane Propellers and Gearing—Lieut. C. H. Havill, U. S. Air Service, Wright Field.

Non-Radial Air-Cooled Engines—S. D. Heron, U. S. Air Service, Wright Field.

2 p. m.—Commercial Operation Session

General Principle of Shock-Absorbers—J. F. Wallace, Cleveland Pneumatic Tool Co.

Care of Passengers—W. G. Herron, Boeing Airplane Co.

Fog-Flying Possibilities—Lieut. A. F. Hegenberger, U. S. Air Service, Wright Field.

Fire Prevention—Representative, Wright Field.

Thursday, Dec. 6

9:30 a. m.—Morning Session

Relation of Production Costs to Quantity Produced—L. S. Milburn, Glenn L. Martin Co.

A Critique of Airplanes—E. P. Lott, National Air Transport, Inc.

Lighter-than-Air Aircraft Developments—Dr. Karl Arnstein, Goodyear-Zeppelin Corp.

2 p. m.—Committee Meeting

Joint meeting on Aeronautical Standardization by the S. A. E. Aeronautic Standards Division and the Commercial Manufacturers' Section of the Aeronautical Chamber of Commerce.

4 p. m.—Open Standards Session

Discussion of Reports of Subdivisions of the S. A. E. Aeronautic Standards Division.

increased interest in matters pertaining to aircraft operation and maintenance is indicative of the strides that have been made in aircraft engine design.

Of interest equal to that of the foregoing papers will be Lieut. C. H. Havill's paper on Airplane Propellers and Gearing. Little has been published on this subject during the last few years and a comprehensive paper discussing the subject in the light of present knowledge should prove most acceptable.

Commercial Operation Session

Subjects scheduled for discussion at the Commercial Operation Session indicate the extensive study that the Aeronautic Meeting Committee has made in preparing the technical program for the Chicago sessions. All four subjects are of vital importance to the industry and warrant discussion by every qualified engineer and executive.

The paper by J. F. Wallace on the General Principles of Shock-Absorbers will discuss not only the present types of shock-absorber and their application on present-day aircraft but their probable future development in the light of present trends.

The papers on Care of Passengers, Fog-Flying Possibilities, and Fire Prevention are on subjects that have both commercial and engineering aspects. The engineers who have accepted the invitation of the Aeronautic Meeting Committee to prepare these papers are authorities, and the Committee is to be congratulated on having made the session program possible.

Thursday Morning Session

Papers for the Thursday morning session, although covering a rather wide range of subjects, are each of particular interest. With the tremendous increase in commercial production, L. S. Milburn's paper on the Relation of Production Costs to Quantity Produced will be very timely. Mr. Milburn's experience, although based on military production, is applicable to commercial production and his paper will make it possible for commercial manufacturers to benefit by his experience.

Of equal importance to commercial manufacturers will be E. P. Lott's paper entitled A Critique of Airplanes. Mr. Lott, an experienced pilot, is now manager of operations for the National Air Transport, and he will present an unbiased analysis of the characteristics of present-day airplanes which should be productive of some highly interesting discussion.

In the paper on Lighter-than-Air Aircraft Developments, Dr. Karl Arnstein, of the Goodyear-Zeppelin Corp., will present the principal features of the dirigible design submitted to the Navy in the recent competition. It is hoped that in addition to Dr. Arnstein's paper there will be a prepared discussion dealing with certain practical developments that may be of general interest or of importance in the handling of future large airships. This discussion is expected to cover the development of the short mooring-mast and various kinds of aircraft trucks and cars for handling dirigible aircraft.

The program for the Chicago Aeronautic Meeting has been arranged by the Aeronautic Technical Program Committee under the chairmanship of Glenn L. Martin. The other members of the Committee are the Hon. Edward P. Warner, Capt. L. M. Woolson, E. D. Osborn, H. M. Crane and Capt. E. S. Land.

Standardization Meetings

To those who are familiar with the history of the activities of the Society in aeronautical engineering and with the large part played by the Society in the development of aircraft standards during the war, the devoting of a Session of the Aeronautic Engineering Meeting to Standards will be of especial interest.

It has been necessary, in keeping up with the march of progress, to cancel many specifications which, while of great value when adopted and for some time afterward, must, because of the advance constantly being made in aircraft development, be superseded by new standards. The 18 aeronautic specifications approved and adopted by the industry last June are proof of the interest in and need for this work. They form, however, only a basis for future standardization work that will unquestionably result in great economy to manufacturers and be an invaluable aid in servicing aircraft, affording benefits such as have been experienced by the automobile manufacturer and user.

The Aeronautic Division of the Standards Committee and the Commercial Manufacturers Section of the Aeronautical Chamber of Commerce have also arranged to hold a meeting on the general question of aeronautical standardization. As the latter organization leaves to the Society the handling of its technical problems, this conference should, and undoubtedly will, produce results that will prove to be of inestimable value to the aircraft manufacturer.

The 1928 Transportation Meeting

(*Continued from p.* 440)

consignments received per day is delivered the same day and 72.2 per cent is delivered the second day. In the largest three Eastern Canada cities more than 97 per cent of inbound carted tonnage is delivered to consignees by the second day after receipt at the railroad sheds. In Eastern Canada the incoming freight is taken by the cartage company for delivery without advice from the consignee only when the consignee has a credit with the railroad company, and collects charges on the deliveries regardless of whether the consignee is on the credit list. In Western Canada incoming freight is given to the carter without any order from the consignee and the railroad collects from the consignee.

Store-door delivery by the systems described has been so satisfactory to shippers and consignees that they successfully opposed proposals made to the Board of Railway Commissioners that the system be abolished.

To Come in United States

Application of a modification of the Canadian system by the Boston & Maine Railroad with some success was described by F. J. Carey, manager of trucking operations of the Boston & Maine Transportation Co., in prepared discussion. Mr. Daniels, of the United States Trucking Corp., voiced his belief that store-door delivery is the solution of the problem of congestion at railroad piers and in the streets of New York City. J. A. Hoffman, vice-president of the Motor Haulage Co., of New York City, was not so sure. He said that it is a big subject and not a matter to jump into over night. It has many merits and is going to come, but will come gradually. Major C. E. Smith, vice-president of the New York, New Haven & Hartford Railroad, stated that New York City offers a peculiarly good opportunity for the store-door collection and delivery of carload freight and possibly for the introduction of a much better method of handling less-carload freight than is now followed.

Present Service Improperly Performed

The reason that the subject is open to so much discussion, said William J. Duffy, general manager of Big 3, Inc., of Boston, is that the service that already exists is not being performed properly in the interest of any of the parties concerned with it. If a regulated store-door delivery system could be installed that would take care of the smaller shipments, so that deliveries could be made to the greatest number of consignees in the smallest area at any one time outside the peak hours of passenger transportation in the industrial centers, it would accomplish definite progress for the railroads, the truckmen, the merchants and the public.

Bigger and better store-door delivery and how to get it seemed to be the purpose of the session, said Billings Wilson, of the Port of New York Authority. It was the fifth meeting of the Society at which a symposium of views on the subject had been presented, he thought, and if these do nothing more they prevent our minds from becoming atrophied. Store-door delivery is not a panacea for all freight-haulage ills, in the opinion of the Port of New York Authority, he said. It will work well in some cases and not in others, because of different conditions that prevail.

Railroad-Shipper Cooperation Needed

In Canada, the railroad terminal facilities in the most important communities have been developed, continued Mr. Wilson, on the basis of store-door delivery of approximately 70 per cent of the less-carload freight, whereas in New York City, where the concentration of freight is intense, the facilities have been developed to provide deliveries at fixed points around the harbor. We should need fewer such facilities if we had organized store-door delivery. But to superimpose such a system on facilities that are adequate under the present system, it is questionable if store-door delivery would result in any economy to the railroad, unless the road is willing to give up the physical facilities it holds and to retrench to effect the economies that might be derived from such a venture. He believes, however, that if properly worked out, store-door delivery will accomplish economies where it is suited to specific problems. It must, however, be developed in cooperation with the railroads and the shipping fraternity.

Various other angles of the problem were touched upon in the discussion, including the attempt made by the Railroad Administration during the World War to initiate store-door delivery in New York City. After careful study of conditions at that time, the project was on the point of being launched when the armistice came. Unsystematic and slow freight-handling methods on piers and in railroad freight-houses, opposition on the part of truckers who fear exclusion from haulage of railroad freight if the system is put into effect, and other adverse conditions were mentioned as obstacles to be overcome.

Mr. Henry's paper, which was illustrated by lantern slides, will be published later in The Journal, together with the pertinent discussion thereon.

Service-Problems Session

Accident Prevention, Vehicle Maintenance and Replacement Problems Treated by E. C. Wood

The last session of the Transportation Meeting, on Friday afternoon, was devoted to service problems, on which E. C. Wood, Pacific Coast Vice-Chairman of the Operation and Maintenance Committee of the Society, presented three papers. The attendance was almost up to the record of the other sessions, and was remarked upon as establishing a new precedent in attendance at a final session of an S.A.E. meeting. This was interpreted as a spontaneous appreciation of the contributions of Mr. Wood and the group of operating men with whom he has worked in an informal organization which he calls the West Coast Committee. Mr. Horine served well as chairman of the session, in the necessary absence of Mr. Glynn.

Mr. Wood's first paper was on the subject of Highway-Safety Education and Accident Prevention, which he says is largely a matter of organization. Proper facilities are needed to promote a free and even flow of traffic, to reduce the accident hazard and the amount of regulation required, with cooperative action for regulation and for education of both driver and pedestrian. Regulation must be supplemented by a sense of personal responsibility.

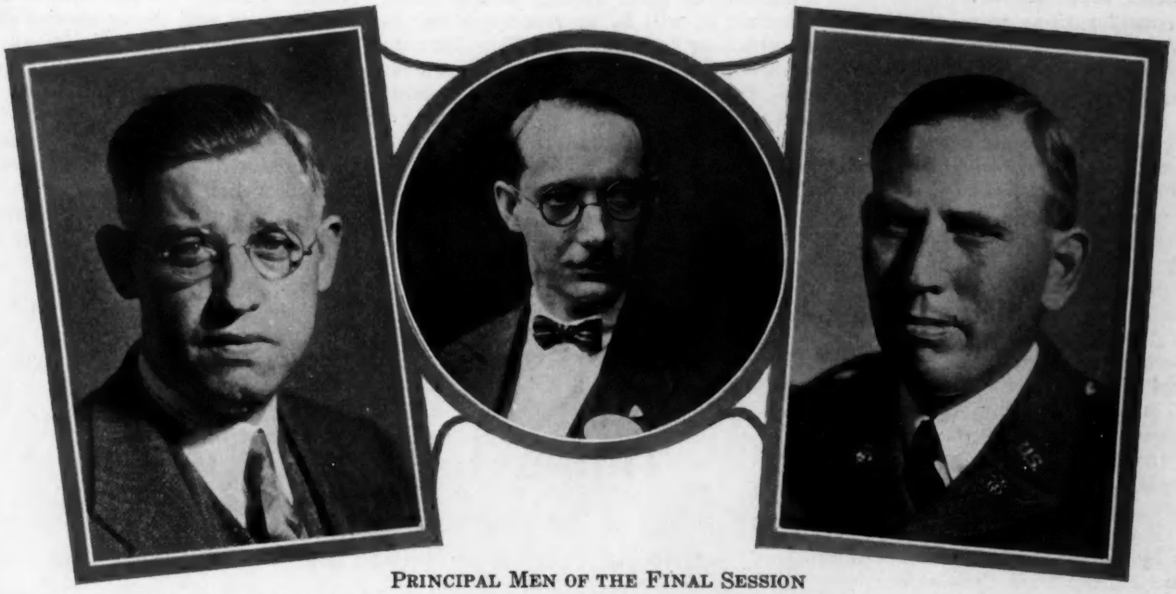
Users of highways who drive recklessly or display flagrant disregard for the rights of others should be prosecuted; and adequate penalties should be applied, including revocation of licenses for cumulative or flagrant offenses. Mr. Wood also advocates impounding vehicles. Speed regulation should be directed at recklessness, with no definite limits lower than 15 m.p.h. in municipalities except in certain zones, the boundaries of which should be marked plainly. Laws and regulations should be uniform.

Information on accidents should be carefully classified. Mr. Wood suggested

18 classifications, giving conditions of the locality, the vehicle and the driver, and including an opinion as to the primary cause of the accident and recommendations for preventive action.

Several diagrams showing conditions found to be most frequently responsible for driving accidents were given. Among them were: Passing another car on a curve where the view is not clear, passing where there is not sufficient room because of vehicles approaching in the opposite direction, passing parked vehicles without sufficient clearance, and passing trolley cars on the wrong side or at street intersections.

Universal adoption of the uniform traffic code, which has been adopted by 43 cities in California, is urged by fleet operators, and also cooperation with the safety movement of the National Automobile Chamber of Commerce.



PRINCIPAL MEN OF THE FINAL SESSION

(Left) E. C. Wood, Who Was Introduced as the "Next Speaker" Three Times by M. C. Horine (Center), Who Acted as End Man. Capt. G. M. Herringshaw (Right), of the Motor Transport School, Took Part in the Discussion

SAFE NUMBER OF WORKING HOURS

There was some discussion of the number of hours or the number of miles that a driver could work per day without fatigue sufficient to contribute to accidents. Mr. Wood said the distance is 40 miles, including city traffic for part of the distance. Capt. G. M. Herringshaw, of Camp Holabird, reported 60 to 80 miles per day as safe figures for Army transportation. He also said that a warm meal at noon, rather than a cold sandwich, makes for better driving. The average speed considered is about 10 m.p.h.

Mr. McDermott, of the Gimbel Bros. Philadelphia store, said he had found that accidents result from assigning too much mileage to a driver, who consequently drives too fast in order to finish his schedule. It has been found best to rearrange the schedule when a distance of 80 or 85 miles is exceeded.

Clinton Brettell, of the Macy store in New York City, reported much the same experience as Mr. McDermott, and said that covering 40 miles in New York City is harder work and results in more accidents than 60 or 70 miles from the suburban stations. Chairman Horine called attention to the difference in possible mileage between drivers who have and those who have not deliveries to make.

PARKING ON A HILL

Mr. Brettell reported that his organization had found it advisable to provide its trucks with chocks attached by small chains, to positively prevent them running away when parked on a hill. Drivers are instructed to use these chocks when they cannot park with the rear wheel cut into the curb. Small cars are left in gear. Mr. Wood reported that oil companies are using chocks while unloading fuel oil, an operation that requires considerable time. Daily inspection of brakes helps.

Coasting hills to save time was reported by Capt. Herringshaw as a prolific cause of accidents. Mr. Wood's cure for this is applied to the driver, and he described it as "nailing him to the cross."

THE ACCIDENT BONUS

The subject of financial rewards for avoiding accidents was introduced by a question from R. M. Creger, of the Public Service Electric & Gas Co., Newark, in regard to giving a bonus. Mr. Wood reported a dry-goods company that based a bonus on combined consideration of mileage, maintenance costs and accident records, and Edward W. Jahn, of the same company, reported that the Safety Council in Baltimore has inaugurated a card system that is proving helpful. After a given period without accidents, a driver is given a class-D card. After further periods he is given class-C, B and A cards, all signed by officers of the company and of the Safety Council. It is expected that the police will give consideration to such evidence of previous good records, and it is surprising how anxious the drivers are to retain their certificates. In some cases a driver may be dropped to a lower class instead of losing his certificate entirely, as a penalty for an accident.

A system of periodic salary reviews was reported by Mr. Brettell as a reward method that has resulted in a reduction of accidents. Chairman Horine regretted the failure of a punch-card system that had been instituted by the Police Department in New York City. This had to be abandoned because of a court ruling that it constituted usurpation of the judicial function by an enforcement officer.

MAINTAINING OR HIRING SERVICE

Mr. Wood's second paper was divided into two parts: first, Is It Cheaper to Maintain a Fleet, or to Hire Vehicles; and second, Is It Cheaper to Farm Out Work or Maintain One's Own Shop? The former was devoted to the experiences of a company that owned about 300 motor-vehicles, divided among 125 trucks, 160 salesmen's cars and a few light delivery cars, and operated in 13 sales divisions in seven western States and Hawaii.

After an attempt at maintenance by centralized stations at Los Angeles, San Francisco, Portland, Spokane and Tacoma, the company sold all its salesmen's cars to the men on the time-payment basis and gave them an operating

allowance based upon mileage. This eliminated trouble over the question of week-end use of the cars and has proved very satisfactory.

In one territory, this company cooperated with two competitors in an arrangement whereby the delivery work of all three was handled by one trucking company, thereby effecting economies for all. Contracts for delivery service were made at other points where only one truck had been maintained; and sales efforts were concentrated more on car-lot shipments by educating the salesmen and adjusting discounts. The total number of automotive vehicles owned by this company today is 78, almost all of them trucks.

Many considerations were mentioned by Mr. Wood as influencing the decision as to how much maintenance work should be done in the shop of the operator. Some firms maintain their fleets with annual overhauls and report it cheaper to have both mechanical and body work done outside when they can assure a certain volume of work to the outside shop. Others, who maintain by unit replacements, have their units rebuilt and repaired by the manufacturer or dealer. Savings are reported from this plan, as the operator can use comparatively unskilled labor, the precision work being done outside. Less capital is invested in shop equipment, and the operator can know the cost of the work in advance.

Some fleet operators believe they can do all their own work to better advantage, as they secure better continuity of service by combining inspection with maintenance. They train their own mechanics and sometimes prefer men who have not had experience in public garages.

A report was given of the experiences of seven large fleets, but Mr. Wood said that some of them have begun the practice of farming out their work so recently that it is not yet safe to draw conclusions from their experiences.

After some discussion of maintenance by outside firms on a mileage basis, figures were given by Mr. Gow on the cost of overhauling in a shop he had recently visited. The six-cylinder engine of a 5-ton truck was rebuilt at a cost of $321. The main bearings had worn 0.047 in., and two of the connecting-rod bearings had worn about 0.030 in. The complete cost of overhauling the truck was $461.78. Mr. Wood reported that a 4 x 5-in. six-cylinder engine would be overhauled on the West Coast for $250, including grinding the cylinder-block and crankshaft and lapping the rings in the pistons. This price includes delivering the block complete, ready for the chassis assembly.

Time to Trade In?

Fleet operators devote much thought to the question of determining the proper time for trading in a motor-vehicle. Determining this time is one of the primary reasons for good cost accounting. Mr. Wood reported that various associations on the Pacific Coast have discussed the question from time to time, and data have been collected from large fleets to help solve the problem.

The proper time to consider trading in a vehicle is when it is about to require major repairs. Fuel expense should not be ignored, as this now is about 25 per cent of the total operating cost, according to Mr. Wood. One of the large operators in Northern California has developed a mathematical formula for determining, at any time, whether it will be more economical to overhaul or to trade in. This formula makes a comparison including depreciation, interest on investment, insurance, and maintenance and operating experiences estimated for both the old and the new vehicle, and predicts the saving or loss that will result from the proposed change at the end of a given time.

Mr. Jahn reported a formula he had been using for several years with fair results but said he was looking for a better one. His formula is less complete than that mentioned by Mr. Wood.

Chairman Horine suggested consideration of the system of keeping a vehicle uptodate by means of unit replacements. Mr. Jahn generally favored trading in a truck when its value becomes doubtful; and Mr. Wood said that, in public-utility work, so much auxiliary equipment sometimes is applied that this warrants installing a new engine.

The question of fatigue of frame material was raised by Mr. Rose, who has observed that frames of cars 8 or 10 years old seem to be more likely to break in a collision, while frames of comparatively new trucks are more likely only to be bent. Mr. Wood reported that, in all his experience with fleet operations, he had never seen a frame cracked. He has frames 25 years old that are still doing service on trailers for hauling poles. Chairman Horine emphasized the point that repairs should be charged on a basis of the time the vehicle has operated before the repairs become necessary. Some of the feeling that operating costs necessarily rise as vehicles grow older is due to the keeping of accounts on a cash basis and to failure of many operators to maintain vehicles on a basis of a stitch in time.

As the sessions closed, a rising vote of thanks was given in appreciation of the contributions of Mr. Wood and those who had worked with him.

Holland Tunnel Visited

Conclusion of Transportation Meeting Marked by Inspection of Vehicular Tubes and Operating Plant

Engineering features of operation, maintenance and traffic control in the Holland vehicular tunnel under the Hudson River between Jersey City and New York City were studied by the members and guests who availed themselves of the opportunity given Saturday morning, Oct. 20, to ride through the tunnel and see one of the four ventilating plants and the traffic-control system in full operation. This inspection trip followed the conclusion of the technical sessions of the Transportation Meeting, and was made possible through the courtesy of the Public Service Corp. of New Jersey, which provided special motorcoach transportation, and that of the Holland Tunnel officials. Ole Singstad, chief engineer and superintendent of the tunnel, delegated a representative to accompany the party and explain the features of interest, and also arranged to divert eastward tunnel-traffic into one roadway and allow the inspection party to ride leisurely through on the other roadway while escorted by a policeman on a motorcycle.

The length of the tunnel is 9250 ft., that of the under-river portion being 5480 ft. Roadway width is 20 ft., and the maximum depth below mean high water is 93 ft. Estimated traffic is 3800 vehicles hourly, with a maximum capacity of 46,000 daily and 15,000,000 yearly.

Carbon Monoxide Gas Banished

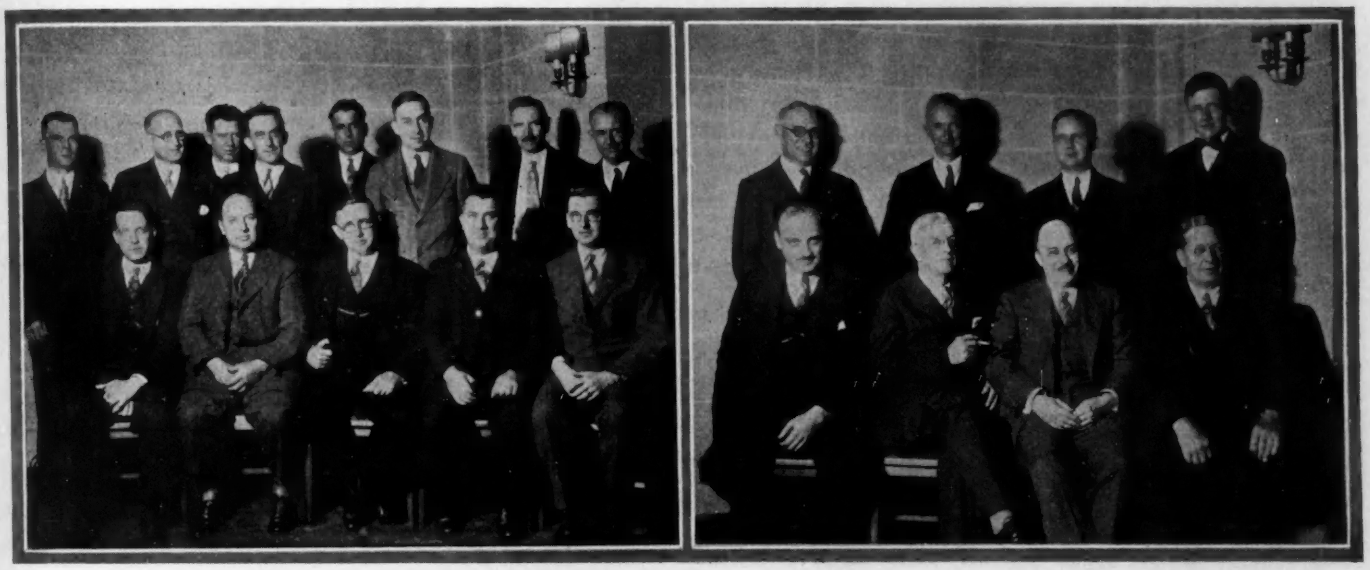
Ventilation is by the transverse distributed method whereby fresh air from a duct underneath the roadway is admitted continuously through openings at each side and air in the tunnel is exhausted continuously through a duct in the tunnel ceiling. There is no longitudinal movement of ventilating air. A complete change of air can thus be made 42 times per hour.

The ventilating-system design resulted from investigations, in which the Bureau of Mines and others cooperated, of the nature and quantity of gases emitted by motor-vehicles under usual road-operation conditions and of the physiological effects of the gases, particularly carbon monoxide. The system is so successful that, although the maximum limit was set at 4 parts of carbon monoxide in 10,000 parts of air, it can restrict the carbon-monoxide content to ½ part in 10,000 parts of air, which is said to be less than that of the air on

(*Concluded on p.* 538)

Registrations at the Transportation Meeting

Abell, A. H., commercial engineer, International Motor Co., New York City.
Albrecht, Fred W., 255 Chancellor Ave., Newark, N. J.
Albrecht, J. H., sales engineer, Wisconsin Parts Co., Cleveland.
Allen, A. M., salesman, Pierce Arrow Motor Car Co., Newark N. J.
Allen, G. D., owner, Deavins Co., Newark, N. J.
Amberg, Frank J., foreman, Public Service Corp. of New Jersey, Newark, N. J.
Amberg, Joseph, foreman, Public Service Corp. of New Jersey, Newark, N. J.
Anderson, George P., director of sales engineering, Dodge Bros. Corp., Detroit.
Anderson, K. W., salesman, Metropolitan Life Insurance Co., New York City.
Anderson, Robert M., professor of mechanical engineering, Stevens Institute of Technology, Hoboken, N. J.
Arham, Everett J., owner, Joseph Arham & Son, New Britain, Conn.
Blackwood, A. J., research laboratories, Standard Oil Development Co., Elizabeth, N. J.
Blair, J. S., assistant secretary and treasurer, Pie Bakeries of America, Inc., Newark, N. J.
Blanchard, Arthur H., highway transport and traffic control consultant, Chicago.
Blanchard, Donald, editor, Chilton Class Journal Co., Philadelphia.
Bleecker, John S., consultant, West Chester, Pa.
Bleyle, Carl A., supervisor, The Texas Co., Boston.
Blood, C. A., traffic manager, Lehigh Valley Railroad, New York City.
Bonnell, C. M., Jr., engineer, freight container bureau, American Railway Association, New York City.
Blum, Fred G., treasurer, Peter J. Blum & Sons, Inc., Newark, N. J.
Blum, Peter J., president, Peter J. Blum & Sons, Inc., Newark, N. J.
Bode, L. A., service manager, Mack Trucks, Inc., New York City.



THE STANDARD OIL DELEGATION AND A GROUP OF MOTOR-TRUCK EXPERTS

J. F. Winchester (First Row, Center) Who Presided at the Business-of-Transportation Session, Was the Leader of the Standard Oil Delegation. The Motor-Truck Experts (Right) in the First Row, Left to Right, Are: T. F. Barry, Secretary of the Merchant Truckmen's Bureau of New York; Day Baker, of the Motor Truck Club of Massachusetts; T. D. Pratt, General Manager of the Motor Truck Association of America; G. W. Daniels, of the United States Trucking Corp.; (Second Row) A. D. Way, Secretary of the Motor Truck Club of New Jersey; F. C. Horner, General Motors Corp.; E. F. Loomis, of the National Automobile Chamber of Commerce; and R. E. Plimpton of Bus Transportation

Armstrong, R. S., assistant secretary, Motor Vehicle Corp., New York City.
Arronet, Herbert A., automobile engineer, United States Army, Rantan Arsenal, N. J.
Aument, H. C., sales, Farrant Sales Corp., New York City.
Autenrieth, George C., professor of mechanical drawing, College of the City of New York, New York City.
Bacon, D. L., supervisor automotive equipment, New York, New Haven & Hartford Railroad Co., New Haven, Conn.
Bean, W. H., special mechanic, Surface Transportation, New York City.
Becker, A. E., in charge lubrication laboratories, Standard Oil Development Co., Elizabeth, N. J.
Banks, W. F., president, Motor Haulage Co., Brooklyn, N. Y.
Beecroft, D., vice-president, Chilton Class Journal Co., New York City.
Benedict, H. H., manager eastern district, Judson Freight Forwarding Co., New York City.
Benham, H. W., New Jersey Bell Telephone Co., Newark, N. J.
Benz, W. R., local manager, International Harvester Co., Newark, N. J.
Bernhardt, I. H., vehicular supervisor, Continental Baking Co., City of Washington.
Bert, F. S., manager, Bert Brothers, Newark, N. J.
Billings, C. M., engineer, Vacuum Oil Co., Newark, N. J.
Bion, John W., assistant purchasing agent, New York Edison Co., New York City.
Birchler, Boman, trucking, George F. Perry & Sons, Inc., Newark, N. J.
Bitner, Edward H., motor-vehicle supervisor, Bell Telephone Co. of Pennsylvania, Harrisburg.
Boehm, A. Bruce, sales manager, Standard Oil Co. of New Jersey, Newark, N. J.
Bole, S. T., salesman, The J. G. Brill Co., Philadelphia.
Bowman, H. L., engineer, Surface Transportation Co., New York City.
Brady, P. M., 635 Newark Ave., Elizabeth, N. J.
Brand, C. L., vice-president, Davis Welding & Mfg. Co., New York City.
Brandmeier, Fred M., president, American Luberite Corp., Long Island City, N. Y.
Bray, W. C., truck and bus tire sales, B. F. Goodrich Co., Akron, Ohio.
Breckenridge, H. K., engineer bus development, West Pennsylvania Railways, Pittsburgh.
Breckenridge, Richard, vice-president, Cincinnati, Hamilton & Dayton Railway, Cincinnati.
Brettell, Clinton, superintendent of garages, R. H. Macy & Co., Inc., New York City.
Brewer, H. G., salesman, Pierce Arrow Sales Corp., Newark, N. J.
Brister, W. B., transportation engineer, The White Co., Long Island City, N. Y.
Brown, A. W., experimental engineer, Fifth Avenue Coach Co., New York City.
Buckendale, L. R., executive engineer, Timken Detroit Axle Co., Detroit.
Burch, Hugh W., assistant to general superintendent of automobile maintenance, Public Service Electric & Gas Co., Newark, N. J.
Burgess, George S., vice-president and secretary, New Jersey State Chamber of Commerce, Newark, N. J.
Burgmeyer, George, owner, Burgmeyer Bros., Newark, N. J.

Burkle, William M., division supervisor, American Telephone & Telegraph Co., New York City.
Burlingham, C. S., assistant to president, West Pennsylvania Railways Co., Pittsburgh.
Burnett, R. S., standards department, S. A. E., New York City.
Burnham, R. H. B., freight traffic manager, Great Northern Railway Co., St. Paul.
Butler, M., vice-president, Cincinnati, Hamilton & Dayton Railway Co., Philadelphia.
Bacon, H. F., president, New Jersey Motor Truck Club, Newark, N. J.
Baker, Day, chairman legislative committee, Motor Truck Club of Massachusetts, Inc., Boston.
Ballantine, N. D., consulting engineer, New York City.
Baum, Harry, College of the City of New York, New York City.
Banghman, C. R. B., branch automobile superintendent, Standard Oil Co., Charlotte, N. C.
Baumgartner, Walter J. chief engineer, Relay Motors, Lima, Ohio.
Beall, A. L., engineer, Vacuum Oil Co., New York City.
Campbell, Worthington, lawyer, New York City.
Carbett, R. F., transportation engineer, Henry L. Doherty & Co., New York City.
Carey, F. J., manager trucking operations, Boston & Maine Transport Co., Boston.
Carroll, Lester, eastern advertising representative, S. A. E., New York City.
Carson, H. S., national business sales representative, Dodge Brothers Corp., New York City.
Carstens, L. P., manager, Inter-City Trucking Co., Newark, N. J.
Cartwright, Dale P., bus equipment, North East Electric Co., Rochester, N. Y.
Case, John R., superintendent of car maintenance, Public Service Railway Co., Newark, N. J.
Casler, R. H., engineer, Westinghouse Air Brake Co., New York City.
Cherniack, Nathan, analyst, Port of New York Authority, New York City.
Chisholm, A., branch automobile superintendent, Standard Oil Co., Columbia, S. C.
Clark, Kilburn D., in charge of sales, eastern division, Buick Motor Co., New York City.
Clarke, J. M., vice-president, Federal Motor Truck Co., Detroit.
Clarkson, C. F., secretary and general manager, S. A. E., New York City.
Clown, John W., Bergen Street, Newark, N. J.
Cobleigh, H. R., secretary of service, National Automobile Chamber of Commerce, New York City.
Coe, C. H., general representative, Public Service Coordinated Transport, Newark, N. J.
Coffey, Paul E., office of engineer of rapid transit, Montreal Tramways Co., Montreal, Canada.
Cole, A. B., acting manager truck and bus division, General Motor Transport Co., New York City.
Cole, F. Harrison, chief inspector, Motor Improvements, Inc., Newark, N. J.
Collins, R. J., superintendent of transportation, Kansas City Power & Light Co., Kansas City, Mo.
Conklin, P. J., delivery superintendent, Abraham & Straus, Brooklyn, N. Y.
Conlon, Leopold F., service inspector, Public Utility Commission of New Jersey, Newark, N. J.
Conover, John H., district manager, Pierce Arrow Motor Car Co., Newark, N. J.
Cooke, Charles B., Jr., senior engineer, Ford, Bacon & Davis, Inc., New York City.
Corbin, Frank J., The Heil Co., Newark, N. J.
Cottrell, James W., technical editor, *Commercial Car Journal* Philadelphia.
Cowan, E. M., Standard Oil Co. of New Jersey, Newark, N. J.
Crawford, Joseph, supervisor of transportation, City of Newark, Newark, N. J.
Cregar, R. M., engineer, Public Service Electric & Gas Co., Newark, N. J.
Cullen, Thomas F., supervisor, Brooklyn Edison Co., Brooklyn, N. Y.
Cumming, W. J., service manager, Six Wheel Co., Philadelphia.
Cummings, E. O., salesman, B. F. Goodrich Co., Newark, N. J.
Dalenz, R. S., New Jersey State Chamber of Commerce, Newark, N. J.
Daly, Francis J., service inspector of traffic, Public Utility Commission, Newark, N. J.
Daniels, George W., assistant to president, United States Trucking Corp., New York City.
Davidson, W. A., Autocar Co., Ardmore, Pa.
Dawson, V. E., motor vehicle superintendent, Standard Oil Co. of New Jersey, Baltimore.
DeCamp, Ralph D., president, DeCamp Bus Lines, Livingston, N. J.
DeCamp, Robert B., superintendent, DeCamp Bus Lines, Livingston, N. J.
de Hass, W. M., mechanic, Gulf Refining Co., Newark, N. J.
Delaney, James, superintendent of maintenance, Franklin Lumber Co., Newark, N. J.
Demaret, Stephen, foreman, Public Service Corp., Newark, N. J.
Dennis, H. A., Armour & Co., Chicago.
Derwin, J. O., special representative, Reo Motor Car Co., New York City.
Devine, John F., solicitor, Scott Bros., Inc., Philadelphia.
Diller, Martin J., inspector, Brooklyn Edison Co., Brooklyn, N. Y.
Dillman, Charles R. Crans Ice Cream Co., Philadelphia.
Dodge, W. C., Jr., vice-president, Ferodo & Asbestos, Inc., New Brunswick, N. J.
Donaldson, W. R., sales engineering, General Motors Export Co., New York City.
Doron, W. B., Fisk Tire Co., New York City.
Dorsch, Charles J., delivery manager, Gimbel Bros., New York City.
Dorst, George, Jr., traveling freight agent, N. Y., N. H. & H. R. R., New York City.
Downing, R. F., supervisor, Armour & Co., Boston.
Drake, Charles, superintendent of transportation, Pie Bakeries of America, Newark, N. J.
Drakes, Charles L., sales department, charge automotive division, SKF Industries, Inc., New York City.
Drumm, C. F., Jr., engineer, Mack Trucks, Inc., New York City.
Du Bois, A. R., owner, Mason Material Yard, Arlington, N. J.
Duffy, William J., general manager, Big 3, Inc., Boston.
Dumont, R. D., president, Fink-Dumont-White, Inc., New York City.
Dunn, William F., garage foreman, Public Service Corp., East Orange, N. J.
Eddy, H. C., street-railway engineer, Public Utility Commission of New Jersey, Newark, N. J.
Edwards, George H., superintendent, Toronto Hydroelectric System, Toronto, Canada.
Eggert, W. H., sales engineer, Zaremba Co., Buffalo.
Elgin, B. W., sales department, Dodge Bros. Corp., Detroit.
Ellicott, Joseph R., Jr., representative, Westinghouse Air Brake Co., New York City.
Englesbe, E. P., vice-president and treasurer, Corks Transportation Line, Bound Brook, N. J.
Everett, Charles J., Tenafly, N. J.
Fagg, C. J., secretary, Newark Chamber of Commerce, Newark, N. J.
Fairbank, A. W., branch automobile superintendent, Standard Oil Co. of New Jersey, Charleston, W. Va.
Farris, Clayton, treasurer, Christie Crawlers, Inc., Newark, N. J.
Fay, H. A. C., eastern manager, Service Recorder Co., New York City.
Fayette, Robert, shop foreman, Public Service Coordinated Transport, Newark, N. J.
Fenner, D. C., manager public works department, Mack Trucks, New York City.
Ferguson, A. D., assistant engineer, Canadian National Railways. Montreal, Canada.
Ferrandon, A. H., director motorcoach division, Dodge Bros., Detroit.
Fielder, R., engineer, eastern representative, General Motors Truck Co., New York City.
Finn, J. A., assistant traffic manager, Overson Motor Service Corp., New York City.
Fisk, L. C., sales engineer, Hyatt Roller Bearing Co., East Orange, N. J.
Fitch, B. F., president, Motor Terminals Co., New York City.
Fitzpatrick, Paul G., supervisor of motor vehicles, American Telephone & Telegraph Co., New York City.
Fox, L. W., sales engineer, Firestone Tire & Rubber Co., Akron, Ohio.
Fraser, L. C., assistant superintendent, Standard Oil Co. of New Jersey, Baltimore.
Freedman, A. H., president, New York & New Brunswick Auto Express Co., Freedman Service, New Brunswick, N. J.
Freeman, F. P., J. G. White Management Co., Newark, N. J.
French, H. H., Motor Terminals Co., New York City.
Frey, George, general sales manager, J. G. Brill Co., Philadelphia.
Frost, A. H., manager manufacturers' service, Vacuum Oil Co., Detroit.
Gurney, E. R., engineer, International Motor Co., Long Island City, N. Y.
Galvin, J. F., president and general manager, Pennoyer Merchants Transfer Co., Chicago.
Gannett, Robert, sales engineer, Norma-Hoffmann Bearings Co., New York City.
Geir, G. C., superintendent of shop, Consolidated Gas & Electric Co., Baltimore.
Gemmer, G. A., chief engineer, National Motor Mfg. Co., Irvington, N. J.
Geschelin, Joseph, engineer, Eisemann Magneto Corp., Brooklyn, N. Y.
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Hammond, W. D., American Freight Service Co., New York City.
Hammond, Louis B., foreman, W. & A. Haines, Newark, N. J.
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Harrison, Robert J., salesman, Brockway Motor Car Co., Hudson County, N. J.
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Jones, Calvin F., garage superintendent, Philadelphia Dairy Co., Philadelphia.
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Noll, Frank J., president, Somerset Bus Co., Irvinton, N. J.
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Sanford, W. W., Skinner Automotive Device Co., Detroit.
Sawyer, George W., motor vehicle supervisor, Sinclair Refining Co., Philadelphia.
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Sheffann, Fisk Tire Co., New York City.
Sherwood, John, foreman, Nutley, N. J.
Shields, J. W., sales engineer, Firestone Tire & Rubber Co., Akron, Ohio.
Sickels, George H., truck transportation manager, Mexican Petroleum Corp., New York City.
Simons, R. D., traffic manager, Mergenthaler Linotype Co., Brooklyn, N. Y.
Sisson, A. H., sales manager, Johns Manville Co., New York City.
Skinner, Arthur A., general sales manager, Leece-Neville Co., Cleveland.
Stager, C. R., general manager, Stager Bros., Caldwell, N. J.
Slocum, Edwin, truck service manager, Pierce Arrow Motor Car Co., Newark, N. J.
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Steinberger, special engineer, Baltimore & Ohio Railroad, Baltimore.
Steiner, A., wholesale supervisor, Sun Oil Co., Philadelphia.
Stoll, C. J., eastern representative, Highland Cabs, New York City.
Stone, W., president, Stone's Express, Inc., Lynn, Mass.
Stone, W. A., salesman, International Harvester Co., Newark, N. J.
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Young, R. M., president, Shand & Jurs Sales Co., Denver.
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Selecting and Training Drivers

Southern California Section Analyzes Coach and Truck Operators' Methods and Studies Safety Measures

MOTORCOACH operators find the selection and training of satisfactory drivers more difficult than do the motor-truck operators, according to F. C. Patton, assistant manager of the Los Angeles Motorcoach Co., who presented a paper on Selecting and Training Drivers at the meeting of the Southern California Section held at the Los Angeles City Club on Oct. 12. The reason is that the motorcoach driver must make contact with the public as an agent for the company and must also make out various reports, each of these requirements requiring a high degree of intelligence.

Other papers on this subject of obtaining satisfactory drivers were prepared by F. D. Howell, vice-president and general manager of the Motor Transit Co., of Los Angeles, whose paper was read in abstract form by Ethelbert Favary; and also by E. C. Wood.

A further subject was Operating Safety Measures, and this was treated by Mr. Favary in connection with his report as chairman of Subcommittee No. 5 of the Operation and Maintenance Committee, which was presented at the Transportation Meeting, Newark, N. J., Oct. 18. Eustace B. Moore, presided as chairman of the Los Angeles meeting, which was preceded by a dinner.

A Coach Company's Methods

Describing his company's method of selecting and training drivers, Mr. Patton said that preference is given to married men between the ages of 24 and 35 years. They must have had experience in driving heavy trucks and must present a fairly good personal appearance. After questioning by the employment clerk, the applicant must solve 20 simple problems in arithmetic in 20 min. and have 80 per cent of the answers correct. This simple test eliminates between 25 and 30 per cent of the applicants. Successful passing of this test is followed by a driving-ability test with the chief supervisor, during which the applicant starts the engine and puts the motorcoach through a required set of movements, such as starting and stopping under different conditions, gearshifting to produce increased or decreased speed, double clutching, and the like. Candidates who pass this test are interviewed by the manager, who outlines the duties, rates of pay, working conditions and what the company expects from its employes. After the interview, the candidate fills out a standard application form covering his record of employment for the preceding five years. He is then listed as subject to call and is on probation for three months while his previous records are investigated. Omissions and false references on the application form result in the applicant's dismissal.

A physical examination of the same character as that given by the railroad companies is required, and the applicant must pass a particularly exacting examination on traffic rules to obtain State and city licenses from the Motor-Vehicle Department and the Board of Public Utilities and Transportation. The first instruction is in the making out of report forms, in details of punching transfers and tickets and as to the basis of the complicated fare and transfer system which in Los Angeles includes liberal transfer privileges between motorcoaches and street-cars. Following a half-day of observance of the instructor's duties, the applicant works with fares and transfers, and on the second day is allowed to operate a motorcoach under the supervision of the instructor, who sits directly behind him. At the end of eight days, he is expected to qualify by both oral and written examination given by the chief instructor. The chief instructor or a supervisor rides with the new driver for several days to observe how well he drives and handles the equipment, and a daily report is made of the progress of the driver.

Safety is considered of major importance, and every accident must be explained personally by the man involved. He is either exonerated or charged with the responsibility. If carelessness is shown, the man is penalized and may be removed from the service. The right-of-way rule is not considered as an excuse for collision, and that "a motorcoach must at all times be under control" is stressed to the utmost. To be "under control" signifies that the vehicle must be able to stop within the range of vision or within the distance that the road is known to be clear. At frequent intervals the men are called together for conferences, during which safety and courtesy are the chief topics.

High Labor Turnover

Quoting from the paper written by Mr. Howell, regarding labor turnover of drivers in one company in 1927, Mr. Favary said that this company uses the latest methods in selecting the best men it can find and trains its own men. The average number of men in service was 120 and the number of men released was 134, or a labor turnover of 111 per cent. As to the reasons for releasing men from the service, 25 were transferred to other departments, 54 resigned and 8 were let go because of reduction of the force. Discharges included 4 on account of speeding, 12 for being blamable in accidents, 1 because of recklessness, 10 for ticket and cash-fare irregularities, and 20 for miscellaneous reasons.

Analyzing the reasons for which the 20 men were discharged, Mr. Favary said that 6 failed to report for their runs, 3 were found in jail, 4 were under the influence of liquor while on duty, 4 were hard on equipment, 1 was appropriating company gasoline, 1 had a poor record in general, and 1 refused to follow instructions.

Special Drivers and Safety Rules

In the course of the discussion, one obstacle which hinders the training of drivers in a special line of business was instanced by E. M. Fitz, of the Shell Oil Co. of California, who said that some of the company's drivers necessarily are chosen because of their special knowledge of their particular branch of the work and that frequently these men do not take kindly to instruction in driving because their vehicles are only incidental to the work. Some of these vehicles have the hardest kind of service and this class of drivers is very hard to reach. Mr. Fitz stated also that his company gets the best results by letting the speed rules originate with the men themselves. In this manner the rules will be for the benefit of the men as well as of the company and, if a rule is wrong, no one will find it out more quickly than will the men concerned.

W. H. Fairbanks, of the Southern California Telephone Co., said that his company maintains a special-agents' department which investigates every accident and designates the person who is to blame. In cases of serious accident or injury to a person, the special agent personally investigates the physical phase of the accident; but a board of five men is immediately appointed which consists of a superintendent, two supervisors and two members of the craft of which the injured person or the responsible person is a member. This board's mission is to determine how such an accident can be avoided in the future.

Safety Education Needed

Instructing Pedestrians and Driver Is Most Effective Accident Preventive, Buffalo Section Members Are Told

EDUCATION of the motorist and the pedestrian is the most effective preventive of traffic accidents, and is inclusive of other measures, although regulation and control of both pedestrian and motorist by statutory mandate may be one of the most effective means for lessening the number of accidents and increasing safety on the public highways. This was the opinion expressed by Henry Seilheimer, Buffalo district manager of the Bureau of Motor Vehicles of the State of New York, at the end of an address on The Traffic Situation presented before 51 members of the Buffalo Section at its monthly meeting on Oct. 2. Vice-Chairman Gustaf Carvelli presided in the absence of Chairman E. W. Kimball.

Analysis of Traffic Accidents

The speaker showed a map of the City of Buffalo, which has a population of 538,000 inhabitants, and tables of traffic accidents that occurred during the year 1927, as compiled by the statistical section of the Bureau of Motor Vehicles. The map showed the areas included by the Buffalo Zoning Commission in the congested area and in the non-congested area, and the statistics were given separately for the two areas. Group 1, for the congested area, included 5 persons killed, all adults; and 235 injured, of whom 191 were adults and 44 children. Group 2, for the non-congested area, or outlying parts of the city, showed 74 persons killed, of whom 51 were adults and 23 children; and 1431 injured, of whom 683 were adults and 748 children.

These tables disclose two salient facts, said Mr. Seilheimer: first, the causes of the greater number of accidents and, second, that the greater number occur in the outlying sections, where traffic is less congested, where no traffic officers are stationed, and where both motorists and pedestrians are less careful about observing ordinances and traffic regulations. A table was shown in which percentages of the accidents resulting from different causes in violation of regulations were given as follows:

Accidents, Per Cent of Total	Cause	Results Deaths	Persons Injured
33	Negligence of motorist	0	21
27	Passing standing street-car	1	16
26	Driving off the roadway	2	15
14	Speeding	4	5
	Total	7	57

Accidents resulting from change of direction of the vehicle were given by percentages as follows:

Per Cent	Cause	Deaths	Persons Injured
40	Making left-hand turn	4	85
22	Skidding	0	48
20	Making right-hand turn	1	44
18	Backing	2	38
	Total	7	215

Causes of accidents in which pedestrians were involved were given by percentages as follows:

Per Cent	Cause	Deaths	Persons Injured
30.5	Children playing in street	18	514
27.0	Crossing at street intersection	29	44
20.0	Crossing between street intersection	16	334
14.2	Walking from behind parked cars	8	239
8.0	Other causes	8	130
	Total	79	1,261

Problem of Playing Children

Although it is to be expected that the greatest number of pedestrian accidents will occur at intersections where, for the most part, pedestrians cross the streets, these figures emphasize the negligence of both pedestrian and motorist at these places, pointed out the speaker, and indicate the need of traffic ordinances against "jaywalking" and their enforcement by the police authorities. It is disappointing, he continued, that, despite all that is being done to instruct children in safety methods, more than 30 per cent of pedestrian accidents happened to children playing in the streets.

Citing comparative figures for New York City and London, Mr. Seilheimer stated that it is three times as dangerous for a child to be on the streets in the English capital as in rural England. Statistics present a condition that is common to other cities and clearly indicate wherein lies the duty of public officials in dealing with the accident problem in cities. Because of the present and increasing congestion in American cities, it is to be expected that the greater number of highway accidents will occur in the cities; hence, the motorist and the pedestrian must be controlled by more strict enforcement of traffic ordinances or regulations.

Trend of the Discussion

Discussion on the paper was largely in the form of questions put to and answered by Mr. Seilheimer. It indicated the feeling that remedial measures might lie in the direction of revoking driving licenses of those who violate the regulations, making every operator pass a road driving-test, adoption of uniform traffic rules, and segregation of traffic lanes flowing in opposite directions.

Engineering and Selling

R. H. Grant Tells Detroit Section That Success Depends on Public Opinion

WHAT the Public Knows About Engineering was the announced subject of the evening meeting of the Detroit Section in the ballroom of the Book-Cadillac on Oct. 2, and R. H. Grant, vice-president of the Chevrolet Motor Car Co., was the speaker. But Mr. Grant, taking advantage of a statement made before the meeting that the subject gave him "a lot of latitude," cagily avoided offending the car-buying public by talking of its knowledge of engineering and, instead, dealt more specifically with the relation existing between engineering and selling.

Secretary L. A. Chaminade reported that, as usual, the Section members turned out in force, 287 being on hand for the delectable dinner and the program of excellent entertainment, and 365 attending the session at 8 p.m. Guests at the speakers' table, in addition to Mr. Grant, were President W. G. Wall and President-Elect W. R. Strickland, of the Society; W. L. Mitchell, vice-president and general manager, and Mr. Fraser, sales manager, of the Chysler Corp.; Mr. Lee, sales manager of Dodge Bros., Inc.; Mr. Stephens, sales manager of the Cadillac Motor Car Co.; E. V. Rickenbacker, of the La Salle sales department of the Cadillac Company; Mr. Peters, vice-president of the Packard Motor Car Co.; and Edward G. Budd, president of the Edward G. Budd Mfg. Co.

In opening the meeting, Chairman Bert J. Lemon enumerated 10 points by which he said the members and officers of the Section, and also the speakers at meetings, should be guided in making this a big year for the Detroit Section.

Announcement was made by Carl

Parsons, chairman of the Body Division Meetings Committee, of the first meeting of the division this season which is reported briefly on a subsequent page of News of Section Meetings. William C. Naylor, chairman of the Aeronautic Division Meetings Committee, announced that the first meeting of that division for this season will be held Nov. 5, with Grover C. Loening as the speaker.

Public Has Decided Opinions

Decided opinions regarding cars are held by the public, although it has little exact knowledge of engineering, Mr. Grant believes. The factor that makes for sucess of a company, he said, is not necessarily the brainiest engineering department, the best production department or the strongest sales department, but what the public says about the product and the organization. Sales departments may be able, for a short time, to overcome the handicap of poor engineering; and good engineering may, for a brief time, overcome poor selling, but no company can exist for long with either condition. Every company and its departments must have plans laid three years in advance, and very definite plans formulated one year in advance, and then must stick to these plans, he said. Not flashy engineering, but a constantly improved product, creates public confidence. Color schemes and the adding of gewgaws have been overdone and now mean nothing in the year's sales volume.

Salesmen and Engineers Alike

Although engineers and salesmen feel that they are the antithesis of each other, they are much alike, asserted Mr. Grant. Salesmen are now working with engineering principles and using so many charts that they are being ridiculed in some quarters. On the other hand, young engineers should be good salesmen. They should first know their own job well, then learn how the public feels about various cars by visiting a few dealers. They should get a broader viewpoint by looking around, for nobody can forecast the trend of public preference.

Automobile companies must know the trend of retail trade three months in advance; some understand the problem and are avoiding overproduction and overstocking their dealers. This work resembles engineering. It is possible, from study of car-registration figures and other data, to project the size of the plant five years ahead and to specify in dealers' contracts, from one to five years in advance, the size of the shops and personnel the dealers will require. Although sales departments do not use slide-rules as yet, they are all the time getting more upon an engineering basis. Thus, they are sending monthly to dealers statistics showing how much should be spent and what their receipts should be. From these statistics they can point out to the dealer where expenses should be reduced and how his profits can be increased. Whenever we talk of "dealer mortality," said Mr. Grant, we may be sure that it is caused by, first, the dealer's lack of business ability, or, second, lack of understanding by the company of the dealer's problems.

Used Cars a Blessing

The used-car problem was pronounced by the speaker the greatest blessing the automobile industry has, because, if fads, fancies and styles did not retire cars from service before they are worn out, the industry could not dispose of more than one-half of the new cars that are produced annually. But if, as some suggest, the factories were to take over the financing of used cars and to consign new cars to the dealer, the dealer would no longer be an independent business-man but a commission salesman for the factory. Mr. Grant urged all to start propaganda about the "blessings of the used car."

The automotive industry is the greatest industry in the world, in Mr. Grant's belief, and it is not threatened from any direction by anything on the horizon. The world must have individual ground-transportation, and this is given best by the automobile, considered from both the utilitarian and the economic viewpoints. Aviation is another type of transportation that is developing rapidly. The automotive business, therefore, is the best one in which a man can invest his money and brains with the expectation of remaining in it for many years and receiving a remuneration that is commensurate with the ability applied.

In concluding, Mr. Grant said that the various departments in an organization are not independent but are interdependent; and the engineering department that can constantly improve the product is better than one that turns out a flashy job now and then, because the former develops public confidence in the product.

Engine Details Described

Chicago Section Hears Group of Manufacturers' Engineers and Sees Motion Pictures of Production

FOLLOWING a dinner on Oct. 2, attended by about 125 members and guests of the Chicago Section, C. A. Pierce, of the Diamond T Motor Truck Co., conducted a symposium on details of engine design and development. Among those attending the meeting were about ten representatives each of the Diamond T, International Harvester, and Studebaker organizations. The total attendance was counted as 165 at the technical session.

Chairman J. W. Tierney conducted a short business session before turning the chairmanship of the meeting over to Mr. Pierce. This had to do with plans for forming an Aeronautic Division of the Section and with membership matters. Mr. Tierney reported that men who are eligible to join the Society often are grateful for being invited to become members. Packs of playing cards inscribed in gold with the insignia of the Section are being given as souvenirs to members who bring in others.

Manufacturing Continental engines was depicted in a motion picture shown and described by L. P. Kalb. Some of the films had been made only a few days before the meeting, so there had not been time to arrange them properly and introduce titles, but this lack was more than made up by Mr. Kalb's explanation.

Developments Shown with Slides

Chairman Pierce presented slides showing a number of engines, beginning with some of the older ones, and traced some of the developments that had been dictated by experience and progress, such as stiffening the cylinder-block and crankshaft and making provision for accessibility and ease of repair. An example of the last was contained in pictures showing the small number of sizes of nuts used on an engine. One of the crankshafts shown was made stiff by shortening the stroke and enlarging the bearing so that the crankpin overlaps the main bearing. This construction makes a short engine possible because the crank webs can be thin.

A Large Industrial Engine

When a four-cylinder Waukesha industrial engine was shown, J. B. Fisher was called upon to describe it. He spoke of the duplex oiling system, in which a fresh-oil pump connected to the main pump feeds oil from an outside tank to the cylinder-walls. This is done because it has been found impossible to secure adequate lubrication of the cylinder barrel in such large engines in the customary way. Mr. Fisher reported that bracing along the sides of some of the engines shown has reduced side deflection from more than 0.030 in. to about one-tenth of that amount. He remarked that 80 to 85 per cent of the heat that passes into the jacket water is estimated to come from the area immediately around the exhaust valve.

He called attention to an automatic

air-valve connected to the carbureter, which allows cold air to enter and dilute the heated air at high speed or at full load. Mention was also made of an automatic relief-valve that allows oil to circulate when it is too cold to flow freely through the strainer.

An overhead-valve motor-truck engine built by the Continental Motors Corp. was illustrated and described by Mr. Kalb, who said that the bearing caps are attached with two rows of bolts on each side. The water-pump is made with a bearing that cannot be reached by water, and is located at the rear of the engine with no accessories driven from it. The overhead-valve construction is preferred by operators, he said, because it is easier to make adjustments and to regrind the valves. Cooling conditions at the exhaust valve were said to be better also.

Details of the Lycoming engine were explained by Chief Engineer E. D. Herrick, who said that many of the features of this engine are conventional. Cooling water enters the block on the side opposite the valves but flows directly across to the valve zone. He mentioned also the advantage of the combined water-pump and radiator-fan. Lubrication of the valve-stem is an important aid in the dissipation of heat.

A Veteran Engine Builder

C. C. Hinkley was introduced as a consultant of the Buda Co. and it was said that his membership in the Society, dating back to 1910, was longer than that of anyone else present. He went into some detail in regard to engine-bearing lubrication, saying that 90 per cent of the heat generated in the bearing is carried out by the oil rather than by radiation from the bearing. This suggests to him the desirability of making provision for cooling the oil.

The most definite prediction Mr. Hinkley was willing to make was that gear drives for camshafts and accessories will be eliminated in favor of chain drives because of their greater quietness and smoothness of operation.

Aluminum pistons were said by Mr. Hinkley to be less desirable in commercial-car and industrial engines than in passenger-car engines, because the higher load-factor causes more heat, and that requires enough metal in an aluminum piston to make it nearly as heavy as a well-designed cast-iron piston. He advocated longer connecting-rods than are now customary.

Returning to the subject of lubrication, Mr. Hinkley remarked on the better film of oil secured in shimless bearings. At high speed, the bearing should run on oil and not on the babbitt; and any opening that allows the oil to escape is a detriment. He deprecated the location of oil holes with reference to ease of machining instead of for correct distribution of the oil, and recommended that all oil holes be drilled in the crankcase, to avoid difficulty from scale that forms inside the tubing.

A Cause of Hot Oil

Mr. Jefferson, who has had racing experience, reported that cool bearings result from providing a bleed hole to facilitate the escape of oil from a bearing and thus make the oil circulate easier. Mr. Hinkley said that the same results can be obtained by giving more clearance to the bearing. Mr. Fisher recommended as few grooves as possible in the bearing, and said he omits them entirely from connecting-rod bearings. He has found that the oil temperature will rise 100 deg. above room temperature in ½ hr. in an engine that is run on a dynamometer by electric power, and will rise 30 to 40 deg. more with the engine running under its own power. Investigation has shown this heating to be due largely to the oil-pump. In testing this, he has circulated a quantity of 4 gal. of oil through the pump at the rate of 2 gal. per min., and the temperature had risen from 60 to 180 deg. in 20 min. He said that a pressure as high as 900 to 1200 lb. per sq. in. is generated in a pump delivering at 40 to 50 lb. per sq. in.

J. C. A. Straub, of the International Harvester Co., confirmed the testimony in regard to heating of oil in the pump, and Mr. Pierce said that he had observed both gears and shafts to be worn badly in pumps that were fitted too tightly. A little relief at the end of the gear teeth is said to prevent the hydraulic lock that causes this.

Fuel Feed to an Engine

Indiana Section Members Discuss Various Fuel Systems and Devices Available

New fuel-feeding devices were treated in the four papers presented at the meeting of the Indiana Section, held at the Hotel Severin, Indianapolis, on Oct. 11. About 200 members and guests were in attendance and the papers were illustrated by lantern slides and motion pictures. In the afternoon, demonstrations of the new devices were given on the Indianapolis Speedway. A dinner preceded the evening technical session. Fred S. Duesenberg was chairman, and President W. G. Wall delivered a short address of welcome.

The humorous feature of the occasion was a demonstration by F. E. Moskovics of a model of a 10-cylinder engine designed to beat the best and afford means for presenting a satirical sketch on engineering construction. Mr. Moskovics endeavored to sell this engine to Lee W. Oldfield, and the lively sales argument, together with Mr. Oldfield's reactions as a buyer, were productive of much amusement.

Fuel-Lift Carbureters

In the paper presented by Robert F. Bracke, chief engineer of the Vacturi Carburetor Co. of Chicago, an outline was given of the development of a commercial fuel-lift carbureter, the object of the research having been to build a carbureter of this type which would compare favorably in price with that of any standard make of gravity-feed carbureter and which would lift its fuel from a low-level supply source under all engine-operating conditions. A further object was to develop this device so that it would lift its fuel by suction, or reduction of pressure produced in the inlet manifold, and thereby eliminate any mechanical or electrical pumps in the carbureter body.

After giving a detailed description of the device and its operation, Mr. Bracke said that, although the development work has been confined to automobile-engine carbureters, the device may become particularly suitable for aircraft engines because the elimination of the usual float mechanism makes it possible to run the carbureter in any position, even unside down, and the closed system materially reduces the fire risk. In addition to the obvious advantages of lower cost and economy of space resulting from the elimination of separate fuel-lifting devices, the carbureter facilitates engine-starting in cold weather because of the perfect atomization effected by the high-velocity airstream through the venturi nozzle, and loading in the manifold is prevented. Mr. Bracke stated also that in power, economy, acceleration and all-round performance the device is comparable with the best gravity-fed carbureters now in common use.

Diaphragm Type of Fuel-Pump

Referring to the fuel-pump manufactured by his company, Frank N. Nutt, of the A. C. Spark Plug Co., said that it is of diaphragm type and is operated by a lever that is given a reciprocating motion of 3/16 to ¼ in. by the camshaft or some other rotating part of the engine. The pump draws fuel from the rear tank, through a sediment chamber and strainer which are a part of the pump unit, and feeds it under pressure to the carbureter in strict proportion to the requirements of the engine. A detailed description was presented and motion pictures of its operation were shown. The ad-

vantages claimed are that the device forms an integral part of the engine, requires no priming, affords better idling and slow-speed performance, furnishes ample fuel for high engine-speed, reduces the fire risk, removes all water and dirt from the fuel, is simple, has few parts, and is reliable and quiet.

Various Fuel-Feed Systems

The use of a booster, a vacuum pump or a trap valve in combination with the vacuum tank of a vacuum fuel-feed system was analyzed by F. G. Whittington, chief engineer of the Stewart-Warner Speedometer Corp. He also gave descriptions of the electromagnetic fuel-pump, the mechanical fuel-pump and carbureter, the combined carbureter and electric pump, and the direct fuel-feed systems. The last-mentioned system eliminates the fuel-pump and is based on the theory that thoroughly vaporized fuel is requisite for complete combustion. Mr. Whittington said that the direct fuel-system meets the compromise requirement between volumetric efficiency and distribution by providing the gases for engine operation in a highly vaporized state, thus permitting large manifolding which in itself is a construction favorable to volumetric efficiency.

Additional favorable construction in this system is the provision for passing part of the charge through more intense heat than is usually found in the present methods of hot-spot applications. This would tend to reduce the volumetric efficiency were it not for the fact that this heated portion constitutes only approximately one-fifth of the charge, the other four-fifths being air admitted at normal temperatures. During passage from the main supply-tank to the air-mixing unit, from which the system derives its name, partial carburetion takes place.

A brief description of the complete installation is as follows: In the main fuel-supply tank a down pipe of approximately 5/8-in. diameter is installed which carries the air to the lowest part of the tank; there it forms a junction with the properly proportioned jetting means and produces a mixture that is carried through a conduit to a heating element mounted directly in the exhaust manifold. At this point very high temperatures are encountered, the heavier part of the mixture being acted upon and the lighter ends passing on through. At the point of vaporization, the heavier ends are passed on to the air-mixing chamber where the gases come entirely under throttle control under usual carbureting conditions.

Metal-Bellows Fuel-Pumps

No attempt was made by J. V. Giesler, chief engineer of the Fulton Sylphon Co., of Knoxville, Tenn., to reveal anything new in the functional operation of fuel-pumps of the metal-bellows type, his paper being simply a discussion of the component parts because the pumps he described have some unique features of construction. In other words, the capacity, efficiency, dependability and cost of metal-bellows pumps were presented. In conclusion Mr. Giesler said that the metal-bellows pump he referred to supplies as much fuel as the carbureter requires, has a pumping capacity greater than most engines require under normal operating service, and performed satisfactorily in road tests which were made.

A general discussion followed the presentation of the papers, and further details of the devices described by the respective authors were given in reply to queries. Among the subjects discussed were the means of obtaining proper balance in fuel systems used in connection with superchargers, high manifold-pressure and its effect, condensation that causes trouble due to freezing at low temperature, and electrical fuel-pumps.

Naval Aeronautics Featured

McCord, Warner and Geisse Tell Pennsylvania Section of Relation of Navy to Aeronautic Progress

At the meeting of the Pennsylvania Section, on Oct. 9, Chairman Adolph Gelpke called Vice-Chairman J. H. Geisse to the chair, since he had arranged for the meeting. There was a good attendance of aeronautic men and automobile service men, who came to hear the addresses of Commander C. G. McCord and Assistant Secretary Edward P. Warner, of the Navy.

Commander McCord drew a parallel between the development of the steel industry for shipbuilding during the decade following the Civil War and the encouragement given to the development of the air-cooled aeronautic engine since the organization of the Bureau of Aeronautics in the Navy Department. He said that engines for lighter-than-air craft may be heavier than for airplanes, including the starting and reversing mechanism. The engines of the Los Angeles weigh about 6 lb. per hp.

The water-recovery apparatus, consisting of very light aluminum-alloy tubing placed outside the envelope, adds to both the weight and the drag. It is interesting to note that about 117 lb. of water is recovered for each 100 lb. of fuel burned.

If the carburetion of an airplane engine can be maintained, the volumetric efficiency falls only in proportion to the reduced resistance as a plane rises to great altitude, hence the performance remains about constant. The Navy requires engines to produce 1 hp-hr. per 0.6 lb. of fuel. Aerodynamically, Commander McCord regards the air-cooled engine as superior to the water-cooled engine for airplanes. The life of the engines is increasing, except for special requirements such as those of an aerial-torpedo plane. Formerly, thorough overhauls were required for the Liberty engines after 100 hr. of flying, but that time has been increased to 300 or 350 hr. for the newer engines. A top overhaul is customary after 10 hr. of flying, and a more thorough inspection is made at the end of 100 hr.

Testing Aircraft Engines

No particular difficulty is experienced in testing water-cooled engines in a laboratory by means of a cradle dynamometer. With an air-cooled engine, the propeller cannot be used for cooling because of the torque that it would absorb, so large blowers must be provided to make an air blast of 120 to 160 m.p.h. This arrangement is used for securing torque, friction horsepower and other efficiency data, but torque-stands are customarily used for duration tests.

In altitude testing the Naval Aircraft Factory does not attempt to put the whole engine under altitude conditions, as is done at the Bureau of Standards, according to Commander McCord, but produces a low temperature by means of a dehumidifier. The air is throttled to the proper rarefaction, and the exhaust is rarefied by means of a blower. With a temperature of —50 to —60 deg. fahr. at the carbureter intake and a pressure of one-third of an atmosphere at the exhaust, conditions of 30,000 ft. altitude are simulated, except for the electrical equipment outside the engine. Magnetos and spark-plugs are less reliable at great altitude.

Aeronautic Accessories Wanted

Commander McCord expressed regret that so few manufacturers seem to be interested in producing accessories to meet the approval tests for aeronautic engines. A good field exists for competition in electrical equipment, gasoline pumps and other accessories. There are very few porcelain spark-plugs, he said, that will pass the approval test.

With present compression ratios, doped fuel is required. Tetraethyl lead that can be added to the gasoline in the airplane is carried by the Naval aviators, but this dope is not available to

commercial operators except by purchasing it in the gasoline.

Variable-pitch propellers still are under development, but the Commander said he does not know of any satisfactory ones that have been tested. Mention was made also of the possibility of placing engines inside the envelope of lighter-than-air craft, with the propeller outside.

More Work for the Navy

Saying that it is very useful to have someone goading us on, Secretary Warner mentioned an editorial suggestion that, since the Weather Bureau has made great progress in forecasting the course of hurricanes, it should be possible for science to find a means of guiding them; that the Navy Department should send a submarine out to fight off an approaching hurricane. The editor asserted that engineers have done more wonderful things than that, and he would not be satisfied until it was done.

In sketching the course of development of aeronautic engines, the Secretary warned against any thought that the ultimate had been achieved. He is confident that the aeronautic Diesel-engine will be ready for trial on a large scale soon, perhaps before the airships recently ordered by the Navy Department are completed. It is expected that these airships will be able to make flights half way around the earth at the equator without landing or refueling. In such long flights a saving of 5 or 10 per cent in fuel consumption will justify an increase of 50 per cent in the weight of the powerplant.

Mention was made of the importance of service tests given to aeronautic powerplants by the Navy and Army Services. It may not be advisable for all engine builders to build for the Services, but those who do not have the advantage of such testing must make other arrangements for extensive testing of their products, much as leading manufacturers of automobiles have provided proving grounds for testing their products. Any engine should be tested enough to assure its running for a long period without structural collapse.

Improving Various Engine Types

Chairman Geisse mentioned some of the engine development work that is being carried on, including work on such supposedly obsolete types as the T-head and V-type engines with an object of reducing the frontal area. The V-type engine mentioned uses a high-boiling-point liquid in the jackets, with no radiator. Other engines mentioned are of the two-cycle type in its various forms. Mr. Geisse said also that some engines now are running 500 hr. between overhauls, corresponding to 50,000 miles of travel.

R. W. A. Brewer spoke of British Service conditions, saying that in Europe efforts are being made to find out why an engine cannot run 1000 hr. between overhauls so that the parts that cause failures can be improved. He recommended that a manufacturer who has a good type should stick to that and develop it, as he believes better progress will be made in this way than by changing from one type to another.

Inspects Malleable-Iron Foundry

Cleveland Section Is Entertained and a Paper on the Use of Castings Presented

About fifty members of the Cleveland Section visited the National Malleable & Steel Castings Co.'s foundry on Monday, Oct. 8, where they were conducted through the works. After a dinner, at which they were guests of the company, Chairman Ferdinand Jehle called to the chair John H. Jaschka, former Chairman of the Section, who had arranged the meeting.

Harry A. Schwartz, manager of research for the company, presented a paper on the Place of Malleable-Iron Castings in the Automotive Industry, taking as his text a familiar passage which he ascribed, with a question mark, to Ruskin:

"There never was a product made,
This truth you must confess,
But what some guy could make it worse,
And sell his junk for less."

Mr. Schwartz said that any material must, first, be good enough, and, second, cheap enough, for its purpose, and that maintenance of quality depends altogether upon the consumer. If a customer is sufficiently desirous of depressing the price, he always can find someone to meet his price.

Castings compete with forged and stamped steel. Sometimes forgings are used because the required quality of steel does not lend itself to any other method of manufacturing. Stampings are limited to rather soft and ductile steel, and their use often involves welding, which cannot improve the quality and may detract from it.

An ordnance officer was quoted as saying that gun barrels can be made better by casting and heat-treating than by forging; and during the war a prominent engineer wished to have crankshafts for Liberty aircraft-engines cast, but such castings were not made because the foundry problems were not solved. The choice between a forging and a casting often depends upon the shape. Obviously, a rivet cannot be cast as cheaply as it can be forged, and an engine cylinder-block cannot be forged.

Stampings and Forgings Compared

Stampings often are lighter and cheaper than castings, and they seldom duplicate the form of the castings they replace. If lightness is permissible and the form serves the purpose, the substitution is good, said Mr. Schwartz; but a part that is easily formed is easily deformed, and a part that is too light is not rigid. A brake-drum that is made by the same process as a shoe-polish box does not function as well as a cast brake-drum, although the best brake-drums are not made from malleable iron.

When the malleable-iron foundry finds that the foundry problem could be made easier by a slight change in a casting, the question of making the change is taken up with the automotive engineer, who, according to Mr. Schwartz, usually says the casting must not be changed. The manufacturer of pressed-steel parts, on the other hand, makes up a stamping and then says, "Mr. Engineer, this does not look like what you have been buying, but it will take its place, and I will sell it for thus-and-so."

Some of the success of pressed steel is due to the elimination of machining; but, if the part requires machining at all, malleable iron is easier to machine than any other ferrous material. Reference was made to a paper on Malleable-Iron Drilling Data, by Mr. Schwartz and W. W. Flagle, read at a Cleveland Section meeting, and printed in The Journal in July, 1922.

At a recent meeting of nine individuals, who were either directing heads or important members of the organizations of malleable-iron manufacturing companies, not one of those present, asserted the speaker, could recall an instance in which some other material had been substituted for malleable iron for any other reason than that the substituted material was cheaper. There have been instances of failure of malleable castings in automotive work, but Mr. Schwartz said that they invariably were castings that were not properly manufactured.

Time of Annealing

One of the handicaps of the producer of malleable iron is the time required for annealing. The long process is expensive and delays delivery. Mr. Schwartz said that the Ford Motor Co. expended about $500,000 trying, without success, to solve this problem, but that progress is being made along this line by leading manufacturers of malleable iron.

In closing, Mr. Schwartz controverted the idea that anything is good enough for a foundry; that nothing is needed but a man with a strong back, a weak head and a pile of sand, and called attention to the many labor-saving devices and methods of accurate control that had been seen by the visitors during their inspection tour.

Numerous Questions Answered

In opening the discussion, Chairman Jaschka called for questions regarding any problems about malleable iron and various kinds of steel castings. Replying to a question from Chief Engineer England, of the F. B. Stearns Co., Mr. Schwartz stated that malleable-iron cylinder-sleeves probably would not resist wear as well as an appropriate grade of grey iron.

Asked for further particulars in regard to reduced time of annealing, Mr. Schwartz said he has seen malleable iron made by two people in as little time as 24 and 36 hr., but this was not done commercially. He said he could not tell how quickly a large quantity of iron had been annealed by his own organization, because the work had been done under conditions that could not be duplicated for its customers.

A question as to threaded malleable-iron parts elicited from Mr. Schwartz the remark that more threaded parts are made from malleable iron than from any other material; and trolley parts, material for high-tension lines, and harvester equipment were mentioned as examples. The shearing strength possible is about 5 per cent less than that of steel, but few nuts are so short that there is danger of shearing the threads.

Methods of Fleet Operation

Motor-Truck and Motorcoach Practices Analyzed at Meeting of New England Section

EVERY business has certain definite requirements and those of a motor-vehicle fleet must be clearly recognized and analyzed before successful fleet-maintenance can be attained, according to a statement by W. M. Clark, superintendent of transportation equipment for the S. S. Pierce Co., of Boston, in a paper he presented at the meeting of the New England Section held Oct. 10 in Boston. Mr. Clark argued that successful fleet maintenance is a result of a compromise, because operation can be built up only on proper and intelligent maintenance; neither operation nor maintenance can be successful unless they are built up together, and each is influenced by the problems of the other.

Other speakers at the meeting were W. W. Beers, of the Gulf Refining Co., whose remarks applied to maintenance of fleets in which motor-trucks operate from widely separated bases; H. Arthur Hall, of C. E. Hall & Sons, Inc., of Somerville, Mass., who described the practice of his company in maintaining a fleet composed mainly of one make of motor-truck; and John H. Walsh, of the Boston & Middlesex Street Railway Co., whose subject was Motorcoach-Fleet Maintenance. The technical session was preceded by a supper at the Engineers Club. K. T. Brown, of the Packard Motor Car Co., Boston, was chairman at the meeting.

Speaking particularly to the voting members of the Section, Albert Lodge, Charles Street Garage Co., Boston, explained the proposed reorganization plan of the Society, as printed in the October issue of THE JOURNAL. He said that all members of the Society should study this article carefully, come to a decision as to whether they favor it or not, and send to the Society's headquarters whatever constructive criticism they may have to offer.

Conditions Affecting Maintenance Methods

In amplifying his subject, Mr. Clark said in part that methods of fleet maintenance are determined by whether the vehicles are localized or are scattered and by the regular and peak demands throughout the day, week, month and year. Scattered location and seasonable peak loads lead to the method of nominal running repairs and periodic overhaul, while localized service and steady operation lead to a maintain-as-you-go policy. Conditions of operation should have a bearing, he said, on the type of vehicle selected. Some systems combine all conditions and both methods of maintenance can be coordinated to give the maintenance department the steady flow of work that is so greatly to be desired.

Despite the lack of uniformity of all of the details of motor-truck cost-systems, Mr. Clark said there is a general similarity in most systems regarding the expense items of storage and garage, gasoline, oil, chassis-repair labor, chassis-repair material, painting, body repairs, and tires. He considered maintenance from the viewpoint of costs, rather than from the single viewpoint of keeping the wheels of the vehicles turning.

Operation of Scattered Vehicles

Mr. Beers said that his company's schedule calls for a complete overhauling of each vehicle every 18 months. The truck is divided into 10 units for the purpose of facilitating record-keeping on the cost of overhauling. Under unit (*a*) is included all repairs to the engine, clutch and ignition system; (*b*) work done on the transmission; (*c*) work on the driveshaft and universal-joints, and brake repairs on trucks having a foot brake connected with the driveshaft; (*d*) rear axle and braking system; (*e*) front axle, steering-column, steering assembly and front wheels; (*f*) chassis assembly, including the removal and installation of all the units, repairs to the springs, shackles and spring rods, and also straightening and reriveting of the chassis; (*g*) body repairs and repairs to the cab, windshield, curtains and battery boxes, (*h*) painting and lettering, (*i*) all electrical work except that done on the ignition system, which is covered as unit (*a*); (*j*) testing, inspecting, delivering, greasing and washing.

The records of costs include the cost per gallon for all tank trucks and for stake-body trucks used for the transportation of products sold by the gallon, the cost per mile on stake-body trucks handling miscellaneous haulage, the mileage per gallon of gasoline, the mileage per gallon of lubricating oil, and the cost of tires. If any truck shows an excessive cost for any one of these items, a careful investigation is made and the trouble is remedied.

Standardization on One Type

Speaking of the maintenance of a fleet composed mainly of one make of motor-truck, Mr. Hall said that the unit system of repair is found most effective and that his company carries in stock completely overhauled units such as engines, transmissions, clutches and radiators, ready for immediate installation. By this means, the trucks are not only kept on the road for a greater number of hours but the men are kept busy at all times. Once a year each truck is cleaned thoroughly with steam and is sent to the shop for overhaul. The covers and plates are removed and the entire vehicle is rigidly inspected. The transmission is cleaned out, gears are replaced or adjusted, and frames and torque-arms are reriveted when necessary. The hood, cab and body and all other parts are put into condition for painting, which is done by the spray method. This overhaul requires one night on the wash-stand, from one to three days in the shop and from three to four days in the paint shop, the total time averaging about one week. Each truck is thoroughly rebuilt after three years of service. Perhaps 75 per cent of the engine trouble is due to valve trouble, and Mr. Hall said also that the valves are therefore refaced and reseated about every 5000 miles for dump-body trucks and about every 10,000 miles for the trucks having platform bodies.

Motorcoach-Fleet Maintenance

The fleet described by Mr. Walsh is composed of 82 four-cylinder-engine motorcoaches, mainly of one make, 47 of which are equipped with air brakes. These vehicles are distributed among five garages; 41 at Waltham, Mass., 18 at Auburndale, 12 at Lexington, 7 at Natick and 4 at Hopkinton. In each garage, except the last, a foreman and such mechanics as are needed to perform the required inspection and repair work, as well as the changing of all units except engines, are employed. The general repair shop is located at Waltham, where all heavy and miscellaneous work is done, inclusive of body repairs and painting, and a general stockroom is also maintained there in which renewal parts of all descriptions are kept available. Mr. Walsh described in detail the inspection methods practised and the processes of cleaning and refinishing the vehicles with fast-drying lacquers.

Questions answered by the several authors during the progress of the discussion had to do with further details of the practices followed by the companies concerned with regard to lubricating, greasing, cleaning, overhauling and oil-reclaiming.

Making Alloy Steel

Electric-Furnace Production of Timken Steel Described at Milwaukee Section Meeting

Motion pictures and still photographs of steel manufacturing, as done at the plant of the Timken Steel & Tube Co., were shown at a meeting of the Milwaukee Section at the Milwaukee Athletic Club, following a dinner, on the evening of Oct. 3. With the showing of the pictures, S. D. Williams, of the Timken company, gave a very informative discussion of steel manufacturing, particularly by the electric-furnace method. Sixty-five members and guests attended the meeting, some of them coming from Chicago.

Less than 5 per cent of the steel manufactured in this Country, said Mr. Williams, is "killed" or fully deoxidized; all alloy steels belong to this class. The greatest tonnage of alloy steel is made in the basic open-hearth furnace, which is suitable for alloys containing such metals as nickel, molybdenum and copper, which do not oxidize in melting; but the electric furnace makes a better product with alloys like chromium, manganese and vanadium.

Production in the open-hearth furnace was described first and illustrated with a picture of an oil-fired 100-ton furnace, which is a size that is commonly used, as it has the virtue of low production cost. Attention was called to the relatively poor control over the process in a furnace of this type, which embodies no fundamental advance since its invention in the days when bicycles were the latest novelty. One of the practical difficulties with this process is that the heat often is tapped at too high a temperature, because the melter knows it will take too long to empty the furnace if the steel is cooler than it should be.

Electric-Furnace Advantages

Whereas only one slag can be taken off in the open-hearth furnace, two slags can be removed in the electric furnace. Charging conditions and regulation also are better with the electric furnace, said Mr. Williams. Most of the electric furnaces in the Timken plant are of the 25-ton size, but a 70-ton furnace is being built with the object of securing better reducing conditions.

To illustrate the action of steel in solidifying, Mr. Williams displayed 20 slides showing paraffin in an aluminum mold having a glass front. Hot paraffin was poured into the mold and the pictures were taken at intervals of 1½ to 2 min. during the cooling. As the material cooled, a distinct cavity was formed. Similar action occurs with cooling steel, and it results in pipes and seams, unless the work is done very carefully. The ingots made at the Timken plant are of the inverted type, with 12 slides.

Alloy steel conducts heat slowly. If an ingot is heated too fast, it will crack with a report as loud as that of a shotgun. The cracked ingot must be scrapped, or failure will occur in service. Cooling must be done slowly also to prevent rupture in the interior of blooms.

Smelter Must Know Requirements

To make a steel as well suited as possible to the customer's needs, the exact requirements must be known in detail. Differences are required in the steel production according to the place of heat-treating in the manufacturing sequence, the process of machining to be used, and the physical properties desired in the product that ultimately reaches the customer.

Speaking of the melter's skill, Mr. Williams said that a good melter can tell the amount of carbon in plain carbon-steel within 2 or 3 points. Great skill is required in determining the temperature in a furnace; the optical pyrometer is used as an aid, but the melter's judgment is final.

The discussion of the fabrication of steel brought out the information that tubes are formed by passing a round bar between two rolls set at an angle. These rolls in some way draw the steel from the center of the billet so that a longitudinal hole is formed. A plug is set in place between the rolls to keep the size of the hole more uniform, but the hole will be formed even without the plug.

Pacific-Coast Steel Industry

Northern California Members Inspect Local Mill and Hear About Western Resources

The Pacific Coast is fast becoming a self-contained unit in regard to its ability to produce steel, according to William Cohn, plant manager for the Columbia Steel Corp., of Pittsburg, Cal. He said that the Coast is no longer dependent upon the eastern producers or upon foreign countries for pig iron, as 85 per cent of the pig iron consumed in the West is produced in Utah. For the open-hearth processes, such basic products as iron ore, magnesite, dolomite, limestone, fire clay, fuel oil, silica, and fire brick are available on the Coast, and a majority of them are produced in California. However, the Coast is still depending upon the East and upon foreign countries for certain ferro materials such as ferromanganese, phosphate, silica, titanium and nickel.

Mr. Cohn's address was presented at the Oct. 11 meeting of the Northern California Section at the Hotel Medanos, at Pittsburg, Cal., where a dinner was served. Those in attendance were guests of the steel corporation, which has the largest plant west of Chicago for producing steel products from Western States coal and iron mines for western demand. Sidney B. Shaw presided at the dinner and W. S. Penfield was Chairman of the Reception Committee. The address of welcome was made by H. C. Chapin, trustee of the City of Pittsburg, who introduced Mr. Cohn as the speaker.

Afterward, an inspection trip was made through the plant of the corporation and an opportunity was afforded for the members and guests to see it in full operation.

Development of the Industry

In 1908 two foundries were operated, one at Pittsburg, Cal., and the other at Portland, Ore., said Mr. Cohn. Approximately 125 men were employed, the monthly payroll being $15,000, and about 400 tons of product were produced per month. Today, the corporation employs approximately 3300 men, the monthly payroll is about $500,000, and the products total about 35,000 tons per month. The first rolling-mill department was put into operation in 1919 and marked the first real step in the progress of the steel industry on the Coast. The company was reorganized and financed by western capital controlled by western men in 1923, and since then the mines and the various properties have been enlarged and developed. Mr. Cohn then went on to enumerate the products made in the different plants operated by the corporation, and to describe the equipment of the properties in general.

Supplementing Mr. Cohn's address, J. Fenstermacher, vice-president of the corporation, said that his company has the essential raw material that eventually will be needed to produce automobile parts. The company's products are sold in all the States west of the Rocky Mountains and some of the States east of them, as well as in the Philippine and Hawaiian Islands, Europe, the Orient, Central and South America.

Night Operation Observed

N. A. Becker, efficiency and consulting engineer for the corporation, had charge of the night inspection trip through the plant, where the full operating forces of all departments were on duty. An opportunity was thus afforded the 198 members and guests to see all details of the various processes, including the operation of an open-hearth furnace of large capacity. They also saw the ingots made when molten metal was poured, as well as the progress of the ingots through the rolling-mill department and their formation into sheet-bars, billets and plates. Sheet steel is made from the sheet-bar, bars and rods from the billets, and wire and nails from the rods.

The Influence of Racing on Car Design

F. E. MOSKOVICS, Lee Oldfield and Louis Chevrolet spoke on the subject of the above title to about 50 members of the Dayton Section at a meeting at the Engineers Club in Dayton, Ohio, on Oct. 8. O. C. Berry, of the Buick Motor Co., was the last speaker and talked on the present aspects of the automotive industry.

Mr. Moskovics eulogized the racing drivers who have met death on the track, likening them to the animals sacrificed in the surgical and medical laboratories for the benefit of humanity. Some of the direct results of experimental research for racing-car development that have come into general use, he said, are balloon tires, wire wheels, fuels of various types, and more effective braking. Deceleration now presents the greatest problem facing the automotive engineer, he asserted. The acme of acceleration has been reached with the present type of high-compression engine, and the difficulty is in minimizing vibration and other negative reactions during deceleration.

Referring to the great experimental work of C. F. Kettering, Mr. Moskovics said the engine-starter was a potent factor in bringing the automobile to its present state of perfection.

Mr. Oldfield talked briefly on the development of the front-wheel-drive type of racing car.

Following delivery of the addresses, the members asked and Mr. Moskovics answered numerous questions pertaining to automobile design and construction.

The Latest in Brake-Linings

Molded Linings Advocated by Metropolitan Section Speakers —Not All Discussers Agree

ANNOUNCED as the first of several meetings to be held by various Sections on the subject of brakes, the Metropolitan Section discussed brake-linings at its October meeting. This meeting was held on the 25th, one week later than the customary date, because of the participation of the Section in the Transportation Meeting in Newark the preceding week. The dinner was attended by more than 150 members and guests, and the audience was more than 100 greater before Chairman Sidney R. Dresser relinquished the gavel to J. F. Creamer, the member of the Papers Committee in charge of the meeting. Among those attending were representatives of about 20 different makers of brake-linings and a number of brake specialists and service men. The first paper went directly to the main subject of the meeting, Molded Brake Linings, and was given by R. H. Soulis, of the Johns-Manville Corp.

The earliest molded lining was similar to millboard, impregnated with a compound and backed with metal, said Mr. Soulis. This was made about 1914, and probably is still in use for some purposes, but it did not prove satisfactory on the two-wheel brakes of the day. The introduction of four-wheel brakes changed the situation and complicated matters so that frequently lining makers were obliged to produce a special grade of lining for each customer to whom they supplied original equipment. In some cases, according to Mr. Soulis, it was even necessary to use emery in the impregnating compound.

Friction Coefficient More Uniform

The use of internal brakes improved wet-weather conditions materially, and molded linings overcame some of the other difficulties, particularly with respect to extreme variations in the coefficient of friction, which caused much trouble with self-energizing brakes. Now cars of 25 different models that are produced in volume are fitted with molded linings, in which the coefficient of friction is uniform, regardless of temperature, and almost the same at high speed as at the instant of stopping. This makes its action more uniform than that of woven material, particularly in self-energizing brakes.

Evidence exists that the surface temperature in brakes can reach a very high figure. Sometimes particles of steel are found embedded in the lining with an impress of the lining indicating that it must have been melted. That no such temperature as this would indicate penetrates the lining is shown by the fact that the asbestos is not destroyed, as it would be if it reached 720 deg. fahr., the temperature at which the water of crystallization is driven out of the material.

Touching upon the subject of brake-drums, Mr. Soulis said that more metal should be added to make them more rigid and to aid in heat dissipation. He considers the drum, not the lining, to be the weakest part of a brake. While not prepared to make definite and final recommendations as to drums, he believes that merely increasing the carbon content of the steel from which they are made is not an important improvement.

In Self-Energizing Brakes

John Sneed, of the Midland Steel Products Co., who is responsible for the Steeldraulic brake, was the second speaker. He said that it devolves upon the engineer to help the manufacturer of brake-linings by cooperating with him. Low pedal-pressure is desired in brakes, and variations in brake-lining dope have been made to increase the

friction coefficient of the lining and make high pedal-pressure unnecessary. As impregnation is not uniform, variations of 100 per cent in the friction coefficient sometimes have been found. Such variations are far too great in a self-energizing brake, causing a variation of 300 to 350 per cent in the total friction. He therefore turned to molded linings, which have a more uniform coefficient of friction, varying between 0.3 and 0.4, and longer life.

Water is said to have less effect on a molded than on a woven lining. In the former, the fibers are parallel to the surface and insulated from each other so that moisture penetrates very little and is driven off quickly, while the fibers in the fabric act as wicks to distribute the moisture throughout its structure. The chief disadvantages Mr. Sneed has found with the molded lining are that its full efficiency is not obtained during the first 300 miles of service and that it is not satisfactory for external brakes.

The Servicing of Brakes

In the absence of Oscar Eskuche, his paper on Brake Maintenance was read by Edward F. Sullivan, who also is with the Warren-Nash Motor Corp. The importance of brakes was emphasized in this paper by comparative figures, given in seconds and feet, for acceleration and deceleration to and from 20 and 50 m.p.h. These showed that the brakes absorb about six times as much horsepower during deceleration as actually is delivered to the wheels from the engine during acceleration, because of the shorter time and distance in which the deceleration must be accomplished.

In harmony with the keynote of the other papers, the author stated that molded linings have been used on Nash cars since 1924, except for the rear wheels of one of the present models. Before that time, Mr. Eskuche said, he had bought many brands of brake-lining, but since then he has concluded that it is best for the service department to follow the recommendation of the car engineer, rather than to waste time in trying to make improvements in regard to this detail. He reports less trouble in reconditioning brakes since that conclusion was reached.

Lack of lubrication and care of the brake mechanism is responsible for much brake trouble. Lubrication stations and brake-service stations are likely to slight this detail. Adequate brake-testing equipment minimizes troubles by serving as a micrometer to locate trouble, but testing is useless unless followed by good service.

Some Braking Tests

Prof. E. H. Lockwood, of Sheffield Scientific School, spoke briefly of mathematical analyses of brake problems upon which he has been working, and emphasizes the importance of the shifting of the load from rear to front wheels during deceleration. In a certain instance the weight on the rear wheels was reduced from 2200 to 1600 lb., during deceleration, while the weight on the front axle was increased from 2000 to 2600 lb. With equal braking effect at front and rear axles, such a car can be stopped from 20 m.p.h. within 24 ft.

A letter was read in which C. P. Grimes told of his experience in a large service station in Syracuse, where he has an 84-ft. drive provided with wheel-alignment and brake-testing apparatus, making possible the testing of a car within 2 min. He considers molded lining harder to apply and finds that it is not stocked by accessory houses. Mr. Grimes said that 80 per cent of the brake trouble is due to oil and grease on the brakes.

This observation was confirmed by Sidney G. Tilden, who conducts four brake-service stations in Brooklyn and Queens and handles as many as 150 cars per day. He also spoke of the importance of uniformity in the coefficient of friction in self-wrapping brakes, because the applying effort as well as the effect per unit of effort varies with the coefficient. He said that molded lining is good on brakes that are designed for it, but that it will not stand so much abuse as the woven lining. If not properly applied, it sometimes will be burned beyond recovery.

Resurfacing of Drums Debated

On the question as to the service to be given in the case of scored brake-drums, Mr. Soulis recommended resurfacing, and said that the so-called Class-A brake-service stations, where this service can be secured, are widely distributed. Mr. Sneed said that Steeldraulic brakes are designed to operate with drums that have not been trued by machining, and he thinks the surface left by the pressing operation is preferable. Even if a drum is scored it should not be resurfaced when new lining is applied, as the grooving of the drum will not cause undue wear of the lining.

There was some discussion of the woven-and-pressed brake-lining. This was said by one of the speakers to be used extensively in Europe; by another, to be used there less than formerly; and by N. J. Reynolds, of Ferodo & Asbestos, Inc., to have been used first and constantly since on the Rolls-Royce car. It was said that the brakes on this car are guaranteed to last three years without relining, and that service has never been required on the basis of this guarantee.

Art and Color in Design

Detroit Section Body Engineers Urged by Richard Bach to Consider Style in Designing

THE automotive industry is just at the beginning of development of the use of style and color, according to a statement made by Richard M. Bach, of the Metropolitan Museum of Art, in New York City, who was the speaker of the evening at the meeting held by the Body Division of the Detroit Section, Oct. 22, in the Book-Cadillac Hotel.

Art and Color in Their Relation to Design was the subject which had attracted the largest number of members and guests ever in attendance at a technical meeting of the Body Division of the Section. Included among the 650 persons present were many who are responsible for the design of our gay-colored roadsters and our stately limousines, and they and others interested in the general activities of the automobile fraternity listened attentively throughout the evening while references were made to Greek temples and ladies' hats, Persian rugs and 5 and 10-cent stores, motorcoaches, streetcars, and what not, in their relation to the style of a motor-car.

The meeting was the first of the season for the body engineers, and William N. Davis, their chairman, body engineer for the Cadillac Motor Car Co., presided. The guests of honor included Ray Dietrich, president of Dietrich, Inc., custom body-builder; Thomas Archer, president of the Ternstedt Mfg. Co.; J. H. Hunt, patent section of the General Motors Corp.; and W. R. Strickland, assistant chief engineer for the Cadillac Motor Car Co. and President-Elect of the Society.

Automobile Can Express Art

Mr. Bach spoke of the works of art of the ancients and said that they were true expressions of the civilizations of their periods. We are rapidly developing a definite style in architecture which, Mr. Bach said, will be representative of the American life of this period. A similar representative result can be obtained by developing a definite style of design for the automobile. He believes that true art can be expressed by the automobile, just as it was expressed by Grecian vases and the Parthenon. Every development of art and of color for the automobiles of today is approved or disapproved by the public in the salesroom, the speaker stated, and when a definite style for automobiles becomes established it will be a composite style resulting from these universal appraisals by motorists.

Personal Notes of the Members

Upson's New Connection

Ralph H. Upson, widely known in aeronautical circles, is now associated with the Aeromarine-Klemm Corp., at Keyport, N. J. The establishment of this new connection marks the end of

RALPH H. UPSON

Mr. Upson's six-year affiliation with the Aircraft Development Corp., in Detroit, as chief engineer. His experience previous to joining the latter organization included ten years' service with the Goodyear Tire & Rubber Co. He joined the Goodyear company as salesman of aeronautic supplies shortly after graduation from Stevens Institute, and in the succeeding years of his association with this company was put in charge of new research work, made manager of the aeronautical department and, in 1917, appointed chief aeronautical engineer. Three years later he resigned this position for the purpose of developing all-metal construction, and held a consulting position for a short time with Alexander Klemin & Associates in New York City. He left this field in 1922 to join the Aircraft Development Corp., for the more active development of all-metal airships.

Mr. Upson became a Member of the Society in 1916, and of the Metropolitan Section in 1922. Several years later he transferred his Section membership to Detroit. During his membership, Mr. Upson has figured largely in the Standards Committee work of the Society. He has been a member of the Aeronautic Division every year since 1920, and has at various times served on the Aeronautical Safety Code Committee, a Sectional Committee under the procedure of the American Engineering Standards Committee. In 1925 he represented the Society at the Conference on Aeronautical Nomenclature of the National Advisory Committee for Aeronautics.

The knowledge of aeronautics possessed by Mr. Upson is unusually comprehensive and his contributions to the Society along this line are of great interest and value. Included among them are various papers on the subject of airships: Aerial Transportation of the Immediate Future, published in the June, 1921, issue of THE JOURNAL and in Part I of TRANSACTIONS for that year; Airships and Their Commercial Possibilities, which appeared in the November, 1919, issue of THE JOURNAL and in Part II of the corresponding TRANSACTIONS; General Fundamentals of Rigid Airship Design, which was published in THE JOURNAL for August, 1919; and Metalclad Rigid Airship Development. This last paper, which included the history and theory of structure, aerodynamic analysis and operation, was printed in 1926 in the February number of THE JOURNAL. Discussion of the paper appeared that same year in the October issue.

Hunsaker Now With Goodyear

Jerome C. Hunsaker has resigned as assistant vice-president of the Bell Telephone Laboratories, Inc., New York City, to become vice-president of the Goodyear Zeppelin Corp., of Akron, Ohio. His headquarters will be in New York City.

Mr. Hunsaker joined the Bell Telephone Laboratories in 1926, just after leaving the Navy, in which he was commander in the Construction Corps. A review of his experience prior to his affiliation with the Bell Telephone Laboratories, together with an account of his participation in Society activities, was published in Personal Notes of the Members in THE JOURNAL for January, 1928.

Young a Captain in Air Reserves

Fred M. Young, president of the Young Radiator Co., of Racine, Wis., has accepted a commission as captain in the Specialist Reserve, Air Corps, United States Army. Mr. Young served as aeronautical engineer and pilot with the United States Air Service both in this Country and overseas during the war, and his return to the Air Service Reserves marks his continuance of interest in this work, with which he has kept in constant contact through his work in the automotive engineering field.

Mr. Young has been engaged in sheet-metal and radiator manufacturing since 1912, when he started with the Wright Cooler & Hood Mfg. Co. as superintendent in charge of radiator production. He left this company in 1918, when he held the position of general manager, to enter the School of Military Aeronautics at the Massachusetts Institute of Technology, whence he was commissioned and later he went on active duty as aeronautical engineer, also becoming a pilot in the Air Service. He served until the close of the war, when he returned to this Country to accept the position of sales engineer with the Perfex Radiator Co., at Racine. He ended his connection with

FRED M. YOUNG

this company in 1923 to organize and become vice-president and general manager of the Racine Radiator Co., and continued with it until the formation last year of his own company, the Young Radiator Co.

Mr. Young has been an interested participant in Society affairs since becoming a Member in 1920. His standardization activities have included membership on the Radiator Division for several years. He has been no less active in Section affairs. In 1925 he

(*Continued on p.* 34)

The 1928 Transportation Meeting

(*Concluded from p.* 522)

Fifth Avenue, New York City, during heavy traffic.

Lighting and Supervisory Control

During the progress through the tunnel and afterward while the party was being shown through the ventilating plant, interesting features of the lighting system, ventilating system and supervisory control were explained to the members of the party by the representative of the tunnel commission. Electric current is obtained from both sides of the Hudson River. On each side of the river current is available from three independent cables any one of which can be fed from either of two generating sources, making a total of four independent generating sources served by six independent cables. Each cable is of sufficient capacity to carry the full tunnel load. Lights in the side walls of the tunnel are spaced about 20 ft. apart. The two main sources of power serve alternate lights so that the failure of one source still leaves half of the lights in service. In addition to a subsidiary control-board in each of the four ventilating plants, from which all equipment in the individual plant can be operated, a central supervisory board located in the administration building provides facilities for operating all of the equipment in the entire tunnel project by the chief operator.

An especially interesting feature is the automatic, continuous sampling and analysis of the exhaust air from the tunnel for carbon-monoxide content. After the sample has passed through an acid solution, it is brought into contact with a catalytic agent and oxidized. The temperature rise caused by oxidization is measured electrically by a thermocouple and is compared with the temperature of boiling water. The card on the recording instrument is graduated so that the carbon-monoxide content is indicated directly on the dial.

Expressions of great appreciation for the privilege of seeing the engineering details of this wonderful tunnel were voiced by the various members of the party at the conclusion of the trip, and they also expressed their satisfaction with the courtesies which had been extended to them.

Applicants Qualified

The following applicants have qualified for admission to the Society between Sept. 10 and Oct. 10, 1928. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (S M) Service Member; (F M) Foreign Member.

Baekeland, George (A) director, assistant to president, assistant secretary, Bakelite Corp., 247 Park Avenue, *New York City*.

Bell, Frank L. (A) plant superintendent, General Motors (Australia) Proprietary, Ltd., City Road, *Victoria, Australia*; (mail) 6 Pretoria Street, Deepdena, E 8.

Bowlus, Claude A. (M) plant equipment engineer, Chrysler Motor Corp., Highland Park, Mich.; (mail) 808 Bates Street, *Birmingham, Mich.*

Brown, James Wesley (A) district manager, Northern California, Moreland Motor Truck Co., *San Francisco*; (mail) Moreland Sales Corp., 35 Van Ness Avenue.

Campbell, George W. (A) proprietor, Pacific Radiator & Fender Works, 3050 Brook Street, *Oakland, Cal.*

Cole, Roy E. (M) director of engineering, Dodge Brothers, Inc., 7900 Joseph Campau Avenue, *Detroit*.

Cromwell, Charles O. (A) manufacturers' representative, 3-125 General Motors Building, *Detroit*.

Deschamps, Desire J. (M) technical manager, Minerva Automobiles, Inc., *New York City*; (mail) 421 West 162nd Street, Apartment 5-E.

Duston, Freeman C. (A) assistant editor, Industrial Press, 140-148 Lafayette Street, *New York City*.

Dyke, Herbert H. (M) member of firm, Dyke Holden & Schaines, 36 West 44th Street, *New York City*.

Elliott, Frank R. (A) field engineer, Ethyl Gasoline Corp., New York City; (mail) R. F. D. No. 1, Box 230, *Covina, Cal.*

Finch, Volney C. (S M) lieutenant, U. S. N., VF-1B Aircraft Squadrons, Battle Fleet, San Diego, Cal.; (mail) 353 Alameda Avenue, *Coronado, Cal.*

Gardiner, George William (A) sole owner, superintendent, Brake Service Co., 1511 West 8th Street, *Los Angeles*.

Goodwin, William George (M) chief chemist, Dayton Rubber Mfg. Co., *Dayton, Ohio*; (mail) 2035 Rustic Road.

Greene, Philip D. (A) research engineer, chemist in charge of friction materials, Asbestos Textile Co., *North Brookfield, Mass.*

Gunning, C. H. (A) service manager, Bresee Chevrolet Co., *Syracuse, N. Y.*; (mail) 714 Carbon Street.

Kinnear, Harry D. (A) sales manager of factory equipment, Gabriel Snubber Mfg. Co., 1407 East 40th Street, *Cleveland*.

Lester, Edward (A) shop superintendent, Shell Co. of California, 513 North 77th Street, *Seattle, Wash.*

McIntyre, Gordon (M) chief chemist, Imperial Oil Refineries, Ltd., *Sarnia, Ont., Canada*.

Merritt, Charles H. 3rd (J) engineering in standards department, Autocar Co., *Ardmore, Pa.*; (mail) 28 St. Pauls Road.

Meyer, Amos F. (J) draftsman, Climax Engineering Co., *Clinton, Iowa*.

Morrell, G. Arthur (A) district manager, Formica Insulation Co., Cincinnati; (mail) 501 Caxton Building, *Cleveland*.

Mueller, C. W. (A) sales manager, Universal Foundry Co., Pine and Warren Streets, *Oshkosh, Wis.*

Nador, Emery N. (M) engine designer, Ford Motor Co., *Dearborn, Mich.*; (mail) 234 Porter Street.

North, Charles Hector (A) instructor, machine, automotive and electric shops, San Francisco Public Schools, Department of Education, *San Francisco*; (mail) 859 34th Avenue.

Novak, J. N. (J) draftsman, Winton Engine Co., *Cleveland*; (mail) 11521 Florian Avenue.

Nulsen, John C. (M) vice-president, general manager, Mahoney-Ryan Aircraft Corp., *Auglum, St. Louis County, Mo.*

Overbeke, John William (J) landing-gear engineer, Glenn L. Martin Co., *Cleveland*; (mail) 2936 Edgehill Road, Cleveland Heights.

Posner, Harry (A) president, Posner Brake Lining Service, Inc., 47 West Kinney Street, *Newark, N. J.*

Prance, Alvin W. (A) F. R. Atkinson Spring Co., 33 Scott Street, *Hamburg, N. Y.*

Rothermel, Royden Albert (A) managing director, Rothermel Corp., Ltd., 24-26 Maddox Street, at Regent Street, *London, W. 1, England*.

Shockey, Newton E. (A) assistant general manager, L. A. Young Spring & Wire Corp., 9200 Russell Street, *Detroit*.

Siers, Alphonse (J) checker, Timken Detroit Axle Co., *Detroit*; (mail) 2334 Richton Avenue.

Smith, Wesley Dixon (A) general manager, Motor Rim & Wheel Service of California, 1367 South Flower Street, *Los Angeles*.

Tanner, Robert Howard (M) lubrication engineer, Imperial Oil, Ltd., 1000 St. Patrick Street, *Montreal, Quebec, Canada*.

Tannewitz, Edward F. (A) president, general manager, Detroit Cord Mfg. Co., 5700 Merritt Avenue, *Detroit*.

Toboldt, William King (A) assistant technical editor, *Automobile Trade Journal*, Chilton Class Journal Co., *Philadelphia*; (mail) 5607 North Mervine Street.

Tolbik, John A. (M) electric welding consultant, 2490 Sturtevant Avenue, *Detroit*.

Turton, Thomas Freemantle (F M) works manager, W & G Du Cros, Ltd., London; (mail) 27 Arlington Gardens, *London, W. 4, England*.

Van Sandwyk, M. C. (A) General Motors South Africa, Ltd., *Port Elizabeth, South Africa*.

Werner, Louis A. (J) sales specification engineer, Continental Motors Corp. Engineering Department, *Detroit*.

Wetzler, Lester Edward (J) designer of methyl chloride refrigerator, A. A. Wickland & Co., Inc., *Chicago*; (mail) Hyde Park Arms Hotel, 5316 Harper Avenue.

Wolff, Ewald J. (M) mechanical engineer, assistant to head of special problems section, General Motors Corp. Research Laboratories, L. G. 67, General Motors Building, *Detroit*.

Applicants for Membership

The applications for membership received between Sept. 15 and Oct. 15, 1928, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

Baker, Lynne Earle, staff engineer, Sinclair Refining Co., *New York City.*

Baldwin, William L., draftsman, Durant Motor Co., *Elizabeth, N. J.*

Barry, William W., sales representative, Crowe Name Plate & Mfg. Co., *Chicago.*

Beale, Chelse A., draftsman, Chevrolet Motor Co., *Detroit.*

Beckhard, Bruno, Outboard Motor Headquarters, Flushing Bridge, *Flushing, N. Y.*

Beisel, Rex B., chief designer (aircraft), Curtiss Aeroplane & Motor Co., Inc., *Garden City, N. Y.*

Bennett, Raymond, installation layout draftsman, Bragg-Kliesrath Corp., *Long Island City, N. Y.*

Beyer, Raymond H., layout man, airplane brakes and wheels, Bendix Brake Co., *South Bend, Ind.*

Bolles, J. H., sales engineer, Delco-Remy Corp., *Anderson, Ind.*

Bramberry, Harry M., engineer, The Perfect Circle Co., *Hagerstown, Ind.*

Bratten, S. A., assistant service manager, Overseas Motor Service Corp., *New York City.*

Brewster, Theodore A., body layout draftsman, Pierce Arrow Motor Car Co., *Buffalo.*

Burg, Ray F., service representative, Graham Brothers, *Stockton, Cal.*

Burgham, Maurice L., mechanical engineer, Edgewater Steel Co., *Pittsburgh.*

Chace, Thomas B., salesman, Dole Valve Co., *Chicago.*

Crowe, Harry F., inspection foreman, Willys-Overland Co., *Toledo, Ohio.*

Daub, Rudolph, designer and checker, Durant Motors, *Elizabeth, N. J.*

Davidson, William H., experimental work, Harley-Davidson Motor Co., *Milwaukee.*

DeSilva, W. B., service engineer, Larrabee-Deyo Motor Truck Co., *Binghamton, N. Y.*

Donaldson, J. G., sales engineer, Long Mfg. Co., *Detroit.*

Druley, Nicholas E., territorial manager, Wilkening Mfg. Co., *Philadelphia.*

Emmons, Claude E., engineering chemist, The Texas Co., *Los Angeles.*

Evans, Stanley Harold, project engineer, General Airplanes Corp., *Buffalo.*

Fenn, Cyril L., experimental engineering, Fairchild Airplane Mfg. Corp., *Farmingdale, L. I.*

Golden, John O., road engineer, International Harvester Co., *Chicago.*

Gompf, Dr. Heinz, service and parts manager, Hansa Automobile Werke, *Varel, Germany.*

Grossman, D. R., vice-president and general manager, Studebaker Corp. of Canada, Ltd., *Walkerville, Ont., Canada.*

Guy Floyd, full-sized-body draftsman, Pierce Arrow Motor Car Co., *Buffalo.*

Harrigan, Daniel Ward, Lieut., U. S. N., VB Squadron One-B, Aircraft Squadrons, Battle Fleet, *San Diego, Cal.*

Harrington, Elvin E., engineering records, International Motor Co., *Allentown, Pa.*

Harris, William W., patent counsel, Continental Motors Corp., *Detroit.*

Hawk, H. B., resident manager, Valvoline Oil Co., *Chelsea, Mass.*

Hertrich, Frederick W., executive engineer, Buick Motor Co., *Flint, Mich.*

Hile, Forest C., draftsman, Bendix Brake Co., *South Bend, Ind.*

Hill, Henry Clinton, test engineer, Wright Aeronautical Corp., *Paterson, N. J.*

Hill, John G., service manager, Oak Ridge Buick Co., Inc., *Yonkers, N. Y.*

Hofmann, Max, research engineer, Waukesha Motor Co., *Waukesha, Wis.*

Hohn, Charles O., industrial sales engineer, American Hammered Piston Ring Co., *Baltimore.*

Hunn, Sidney M., Jr., production department, Fairchild Airplane Mfg. Corp., *Farmingdale, L. I.*

Iseler, Charles W., research engineer, General Motors Corp., Research Laboratories, *Detroit.*

James, Gordon, vice-president and general manager, Canadian S. K. F. Co., Ltd., *Toronto, Ont., Canada.*

Jensen, Gunnar, designer, Walker Mfg. Co., *Racine, Wis.*

Jones, Malcolm S., treasurer, Perfect Oil Products Co., *Boston.*

Kinkade, T. H., sales engineer, aviation division, Lycoming Mfg. Co., *Williamsport, Pa.*

Komarnitsky, Rostislaw S., assistant chief engineer, Gates-Day Aircraft Corp., *Paterson, N. J.*

Krieter, Harry Rudolf, assistant superintendent in charge of development, design and engineering, Burgess-Norton Mfg. Co., *Geneva, Ill.*

Kruse, F. John, treasurer, Kruse Motor Co., Inc., *Brooklyn, N. Y.*

Land, Emory Scott, Captain, Bureau of Aeronautics Construction Corps, *City of Washington.*

Leisy, Clifford J., staff engineer, Glenn L. Martin Co., *Cleveland.*

Loranger, Louis J., salesman, Long Mfg. Co., *Detroit.*

Losowich, W. C., experimental engineer, Eclipse Machine Co., *East Orange, N. J.*

Lovejoy, Frank W., manager, Vacuum Oil Co., *New York City.*

Lunde, Otto H., aerodynamics and stress analysis, Fairchild Airplane Mfg. Co., *Farmingdale, L. I.*

Lunnon, James, maintenance engineer, Rolls-Royce of America, Ltd., *Springfield, Mass.*

Macauley, Edward R., assistant to vice-president of distribution, Packard Motor Car Co., *Detroit.*

Macy, Frank H., sales and service, The A. C. E. Shop, Inc., *Chicago.*

Mathis, Clyde C., district service manager, The White Co., *Pittsburgh.*

McWhinney, Henry G., Jr., test engineer, Wright Aeronautical Corp., *Paterson, N. J.*

Northup, Amos Earl, chief designer, Willys-Overland, Inc., *Toledo, Ohio.*

Orr, John M., general manager, Equitable Auto Co., *Pittsburgh.*

Parker, Harry D., manager automotive chain division, Ramsey Chain Co., Inc., *Albany, N. Y.*

Pizzo, Joseph, designer, General Motors Corp., *Detroit.*

Putman, Frank W., division superintendent, experimental work, Studebaker Corp., *South Bend, Ind.*

Renno, Arthur A., lubrication, The Texas Co., *New York City*

Ricart, W. P., director and chief engineer, Automobiles Ricart-España, *San Andres, Barcelona, Spain.*

Robb, James C., manager, new department, The J. G. Brill Co., *Philadelphia.*

Ronco, Bunny V., assistant test engineer, International Motor Co., *Allentown, Pa.*

Rudolph, Samuel W., service manager, Harper & Harper, *Philadelphia.*

Rushton, Benjamin, technical manager, Delco-Remy Hyatt, Ltd., *London England.*

Say, F. M., mechanic, Universal Airline System, Inc., *Chicago.*

Schmutz, E. R., proprietor, Chrysler Service, *Vallejo, Cal.*

Schwedes, Harold F., tool designer, Fairchild Airplane Mfg. Corp., *Farmingdale, L. I.*

Seibert, Richard W., foreman of repairs, automotive equipment, The Texas Co., *Long Island City, N. Y.*

Semenyna, Waldimir, designing, Gates-Day Aircraft Corp., *Paterson, N. J.*

Sizaire, consulting engineer, Sizaire Freres, *Seine, France.*

Skillings, C. T., salesman, Autocar Sales & Service Co., *Oakland, Cal.*

Smiling, Bruno M., designer, Fairchild Airplane Mfg. Corp., *Farmingdale, L. I.*

Smothergill, Joseph C., assistant to chief inspector, Fairchild Airplane Mfg. Corp., *Farmingdale, L. I.*

Sorokin, Mark L., president and managing director, Automobile Trust, *Moscow, U. S. S. R.*

Southern Pacific Co., *San Francisco.*

Steindler, N. H., chief lubricating engineer, The Texas Co., *Chicago.*

Stephens, F. A., mechanic and tester, Studebaker Corp., *South Bend, Ind.*

Stevens, Hoy, assistant superintendent of maintenance, motorcoach department, Cleveland Railway Co., *Cleveland.*

Tamarelli, Albert J., chief inspector, Budd Wheel Co., *Detroit.*

Underwood, Arthur J., technical test assistant, Chevrolet Motor Co., *Detroit.*

van Storp, Hans A., designer, Federal Mogul Corp., *Detroit.*

Webster, Robert Masson, Jr., draftsman, American Die & Tool Co., *Reading, Pa.*

Whitney, Alexander, electrical draftsman, The J. G. Brill Co., *Philadelphia.*

Wickwire, Warren E., vehicular supervisor, Continental Baking Co., *New York City.*

Williams, Clifford V., sales engineer, Delco-Remy Corp., *Detroit.*

Wilson, Albert E., draftsman, Hupp Motor Car Corp., *Detroit.*

Wood, C. A., manager, Wood Brothers, *Oakland, Cal.*

Wright, Theodore Paul, chief engineer, Curtiss Aeroplane & Motor Co., Inc., *Garden City, N. Y.*

Ziegler, Edwin S., treasurer, York-Hoover Body Corp., *York, Pa.*

Zufall, Earl T., mechanic, Interstate Public Service Co., *Louisville, Ky.*

Notes and Reviews

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

AIRCRAFT

The 16th Wilbur Wright Memorial Lecture. By F. Handley Page. Published in *The Journal of The Royal Aeronautical Society*, August, 1928, p. 649. [A-1]

In this lecture, delivered before the Royal Aeronautical Society, Mr. Page paid tribute to the pioneer work of the Wrights and their development of the aileron, and in this connection gave a detailed description of recent tests and observations on various arrangements of the slotted wing. A series of photographs show the flow around a plane moved through water on the surface of which light aluminum powder had been sprinkled. These photographs were taken in a small water-tank, the model being held in a frame and drawn through the water by a light cord attached to the pulley-wheel of a small electric motor. Pictures were taken at various angles of incidence with the slot open and with the slot closed.

Mr. Page points out that the test results given in the lecture were prepared mainly to aid in the best application of the slotted wing for control purposes, so that, with the extension of the angular range in which it is safe to fly and the provision of adequate control throughout, the main source of air accidents and the chief bar to the wider use of airplanes can be removed.

Airscrews. By W. E. Park. Published in *The Journal of the Royal Aeronautical Society*, August, 1928, p. 706. [A-1]

The paper was written from the point of view of the propeller builder. The type of wooden propeller standardized in England by the Air Ministry is described, the description covering design, drawing, construction, gluing, rough shaping, finished shaping, finishing processes, and special forms of wooden construction.

The possibility of difficulties in maintaining the supply of material, all of which is imported, has prompted the English to investigate the production of metal propellers. The Leitner-Watts steel propeller, the Fairey-Reed light-alloy propeller, and the newer features of construction, such as the short-type hub-socket, are described and compared with the standard types. The discussion following the presentation of the paper before the Royal Aeronautical Society is also included.

Regarding the National Air Tour. By John T. Nevill. Published in *Aviation*, Aug. 25, 1928, p. 594. [A-2]

In answer to the popular question, What did the 1928 National Air Tour prove in the way of airplane reliability and efficiency? Mr. Nevill recites the facts—25 airplanes transported approximately 70 men and women 6600 miles in about 70 hr. flying time. The author records the varied temperatures encountered, describes the character of the country covered, and gives a detailed description of the airplanes entered and their records in the tour.

The Alignment and Inspection of Components. By R. C. Taylor. Published in *The Journal of The Royal Aeronautical Society*, August, 1928, p. 721. [A-2]

Mr. Taylor's paper is a continuation of the one read before the last session of the Yeovil Branch of the Royal Aeronautical Society and was prepared particularly for those who wish to secure a ground engineer's license. The first part of the paper dealt with the alignment and checking of fuselages; the second part, with the alignment and inspection of certain other components. The author includes the alignment of main and tail planes, fins and controlling surfaces, and of engine mountings; covered-type components; fuel, oil and water tanks; radiators; and fuel, oil and water-system accessories. The article is very comprehensive, and a considerable contribution to its clarity is made in the form of diagrams of airplane parts and testing apparatus.

Airport Development in Oregon. By John W. Anderson. Published in *Aviation*, Sept. 1, 1928, p. 697. [A-4]

Oregon plans to have 52 airports in use by Jan. 1, 1929, a development which has mostly come about in the last two years. The State's interest in aviation was maintained for several years solely by barnstorming fliers and Army pilots on forest-fire patrol. In 1924 the State Department of the American Legion adopted a policy of airport promotion, and since then the Legion has been constantly talking to municipal authorities about airports. Next came the Air Mail, followed by Colonel Lindbergh's western tour, the Spokane air races, the arrival of regular air-passenger-lines and this year's National Air Tour, which seem to have thoroughly persuaded Oregon that flying is a real industry much to be desired.

Articles on airport development in the States of Washington and California and on air-line progress on the Pacific Coast appear in the same issue.

CHASSIS

Light Thrown on Rear-Axle Design by New Performance Tests. By P. C. Ackerman. Published in *Automotive Industries*, Sept. 1, 1928, p. 292. [C-1]

The Timken Roller Bearing Co. has instituted an engineering service that is at the disposal of any manufacturer of automotive equipment, and established an engineering laboratory that is equipped to make a wide variety of tests either to determine the actual performance characteristics of existing mechanisms or to furnish data that may be helpful in the development of new designs.

As an example of the work being done in the laboratory, a deflection test for determining the characteristics of pinion and ring-gear operation in rear axles is described. The results of this test, when analyzed, give very definite clews to actual conditions in the axle, and quite often are the means of suggesting changes in design or construction. Another test known as the "four-square" test is particularly valuable as a life test of the gears and bearings, but also furnishes considerable information as to the performance of propeller-shafts at various angles of inclination.

A New Vacuum Servo. Published in *The Automobile Engineer*, August, 1928, p. 289. [C-1]

To meet a general demand for power-operated brakes, the DeMonge system has been designed in which the braking is directly proportional to pedal pressure. The working principles of this system, which is Belgian in origin, are similar to those in other existing schemes, but there are distinctive and additional features. The force exerted

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